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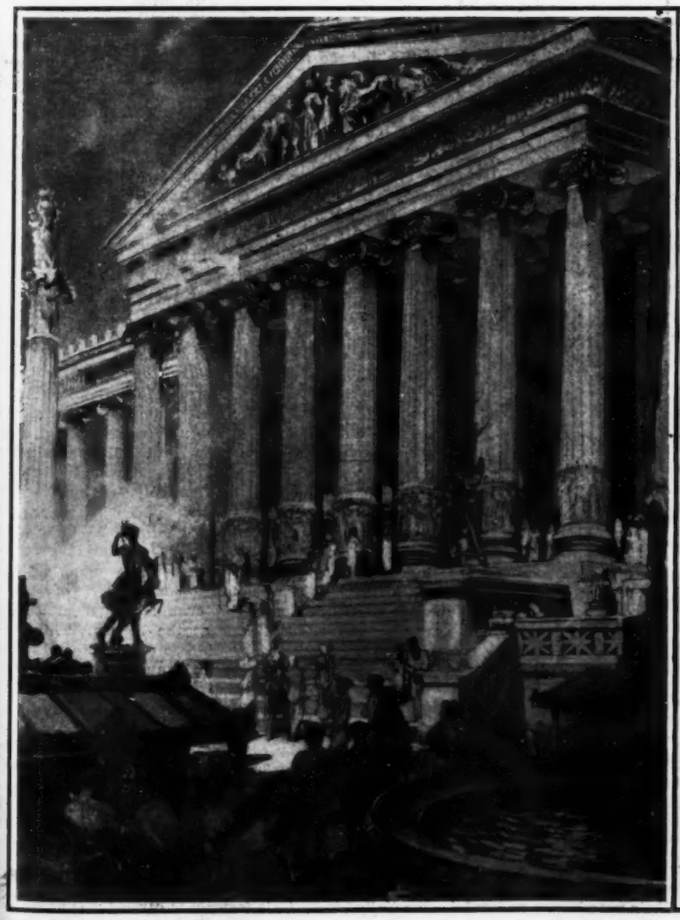
THE PHAROS OF ALEXANDRIA.

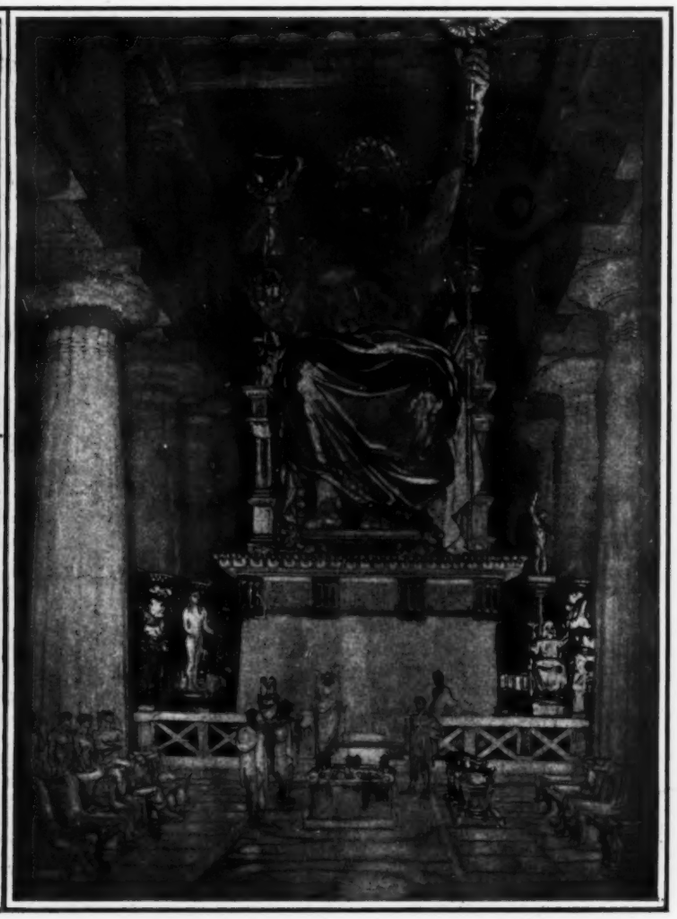
THE COLOSSUS OF RHODES.



By courtesy of the Sphere.

PROCESSION PASSING DOWN THE STEPS OF THE GREAT TEMPLE OF DIANA.

The Temple of Diana had a magnificent pillared frontage and was a treasure-house of Greek art.



From paintings by Kupka.

WORSHIPERS BENEATH THE GREAT STATUE OF JUPITER AT OLYMPIA.

The statue was the work of the Greek sculptor Phidias.

THE SEVEN WONDERS OF THE WORLD.—[SEE PAGE 120.]

THE CHINESE CALENDAR.

HOW THE CHINESE ARRANGE THE YEARS AND MONTHS.

BY DANIEL ARTHUR.

Good fortune, long life, and happiness to the Chinese. Their new year day has begun. It will be the year second of the present Emperor Hsuan Tung. It will also be the 4681st year of their great man Kung Fu Tze (a name we have latinized into Confucius). It is also the year 4607 from the beginning of the reign of the yellow Emperor Hwang Ti, and as the sexagenary system was started on the 60th year of his reign by Nao the Great (the then prime minister) it makes the coming Chinese year 4547, or the 47th year of the 76th cycle of 60 years. Some American almanacs make the mistake of assuming that the 76th cycle is completed and that the Chinese have entered the next to the extent of 47 years. That is to say, they multiply 76 by 60 and add 47, while they should make it thus 75 cycles of 60 completed plus 47, which is the distance entered into the 76th = 75 × 60 + 47 = 4547. The conflict may have come about in the assumption that the sexagenary system began with the reign of Whang Ki 2697 B. C. instead of at the 60th year of his reign, 2637 B. C. But in that event we would have to say that the coming Chinese year was the 47th of the 77th cycle. It is quite well established, however, that the cycle system began in the year 2637 B. C. Add to this our A. D. date 1910 = 4547. This also fits the contention that the current cycle runs from 1864 to 1923. When we go a few thousands of years into B. C. history of China, we find the rulers living to the age of hundreds of years. When I jokingly asked my friend in the Chinese consul's office in New York if it might be possible that these were "short-weight" years, he strenuously said, no, no, that these Chinese gentlemen knew how to live. Our jolly Chinese scholar and diplomat Wu Ting Fang said he would pay America another visit in 1959. This will be the year of the Boar Ki Kai, or the 36th year of the 77th cycle.

On Tuesday night of this month of February, as twelve struck on New York bells, the arrival of Wednesday the 9th was announced and with it the new year day of the first installment of United States Chinamen. Very few of these Chinamen living in our Eastern time zone, which includes the capital at Washington in its zigzag boundary line, realized that they were ushering in their year some twelve hours before it arrived in their home country, while they should have been about twelve hours after China. American almanacs quite properly say that Chinese new year day is February 10th. The Chinese merchants and bankers of the United States still continue to make this curious mistake, which began in a very simple way. The Chinamen coming east across the Pacific "against the sun" arrived, with their almanacs and calendars, at San Francisco and then journeyed across the continent to New York. Other Chinamen left China and traveled across Europe "with the sun," and then to New York *via* the Atlantic, also bringing their unaltered calendar with them. A date line did not happen to be worth while noticing by either of these streams of travelers, so, when they compared notes at New York, the men coming off the Atlantic steamers declared that those coming *via* San Francisco had made a mistake in the name and number of their day, that they had jumped a day ahead. The others charged that the Atlantic travelers had slept through two nights somewhere without knowing it and had therefore lost a day, so to speak. Both sets of men were as much right as they were wrong, but neither of them had recognized a date line in any part of the world. There is no special place where a date line should be, other than that it should be stuck in some out-of-the-way place where busy or forgetful people would not be bothered with it. That is why it was put where it is at the 180th meridian, with a few deflections for local convenience, or as the Dublin wit said, "If the Astronomer Royal at Greenwich put the line any farther from home, it would get nearer." As more Chinamen came to America *via* the Pacific than the other way, the larger party unconsciously forced the minority to set the date line in the Atlantic where it has since stayed without even being known to any but a few Chinamen. It would of course be far better for China to use the "international date line," and in a certain sense she does so in a semi-official way now. But it would be a great convenience to Chinamen both at home and abroad if Emperor Hsuan Tung would issue an edict through the Chinese Legation at Washington that all Chinese-American calendar printers recognize the now established Pacific line and therefore follow the home country in its gala days and dragon feasts instead of anticipating them by a day in an indefinite way. I am informed by the Hydrographic Office of the United States Navy Department that China has now officially inaugurated or copied our 15 deg. hourly zone system in China. This will of course be slow to reach local merchants in China, but as that country is 60 deg. or four hours wide, her railroads running east and west will soon see the advantage of the hour zone system.

正月小 宣統二年 歲次庚戌
SECOND YEAR OF PRESENT EMPEROR, HSUAN TUNG.
SIXTH DAY SATURDAY
FIFTH DAY FRIDAY
FOURTH DAY THURSDAY
THIRD DAY WEDNESDAY
SECOND DAY TUESDAY
FIRST DAY MONDAY
SUN WORSHIP DAY SUNDAY
FEB.12. FEB.11. FEB.10. FEB.9.
FEB.19. FEB.18. FEB.17. FEB.16. FEB.15. FEB.14. FEB.13.
FEB.26. FEB.25. FEB.24. FEB.23. FEB.22. FEB.21. FEB.20.
MAR.5. MAR.4. MAR.3. MAR.2. MAR.1. FEB.28 FEB.27.
MAR.9. MAR.8. MAR.7. MAR.6.
西歷一千九百壹十年
CHRISTIAN STYLE ONE THOUSAND & NINE HUNDRED & TENTH YEAR (1910) NEARLY
孔子降生二千四百六十壹年
CHINESE YEAR FOUR THOUSAND SIX HUNDRED & SEVEN = 47TH YEAR OF 76TH CYCLE OF SIXTY YEARS

THE FIRST MONTH OF THE CHINESE NEW YEAR.

Now for a word on the accompanying illustrations. The square one is the first sheet or month of the above-mentioned new year, and the long cut is a complete sexagenary cycle with translations. We will take up the first month of the Chinese year, and later speak of the curious formation of the cycle.

In the upper right-hand corner of the calendar sheet you will notice four characters. They mean read toward left and downward. The three larger ones to the left translate into first moon small or first month 29 days. Almost all eastern calendars are lunar ones; that is to say, are based on moons or lunations. As this unit is approximately 29½ days, the Chinese consistently make their months 29 days and 30 days (none

A CHINESE CALENDAR CLOCK.

of 28 or 31 days). Their month always begins and ends when the moon is between the sun and the earth (the dark or new moon). Their year begins and ends the same way. That is to say, new year day is a new moon, and so of course must be the last day of the year. As there are 31 of these new moons in about 2½ equinoctial years, or say about 62 of them in five years, China must get them all in to keep her seasons from making complete rotations. China bases her year on a twelve-month or twelve-moon plan. The added or intercalary units are whole months, one of which she must add every 30 months, or let us say twice in every five years. This means that two years out of every five years contain 13 months, or say 383 or 384 days, the other three years being 12 months long, consisting of say 354 days. Although the 29 and 30 day month is planned to keep seasons correct so far as long periods are concerned, it will readily be seen that within these five-year cycles seasons go wrong more than a month. This leads to the necessity of having a set of planting, reaping, fishing, and hunting instructions for every year which partly accounts for the numerous pages in the Chinese almanac. This curious book, which has no advertisements and is said to have the largest circulation or sale of any book in the world, shows that the closing year, the year of the bird or chicken or rooster or cock, had 13 months, consisting of a first month, a "true" second month, an intercalary second month. Then come the third, fourth, fifth, and so on up to the twelfth and last month, which is really the thirteenth. This year contained 383 days and began in America January 21st, 1909, and will end February 8th, 1910. But to come back to the calendar month, the eight characters other than the ones above mentioned mean second year of the present Emperor Hsuan Tung. At the bottom of the cut the line of 9 means Christian style 1910 nearly. The lower set of 12 characters reading toward the left mean Confucius year 2461. This great man's family name was Kung and his given name Tze. We would read it Mr. Tze Kung. China gave him a sort of honorary title called Fu in Chinese, so he became Kung Fu Tze, as his countrymen knew him. We have latinized this whole proceeding into Confucius.

The top rows of squares show the days of the week, beginning with special sun worship day, followed by first to sixth days, Monday to Saturday. Why seven days? Some say because these were seven original stars to the Chinese. Others point out to us that China has 28 stellar mansions, numbered 1 to 28, and that the 4th. 11th, 18th, and 25th of these were halting places for the sun, and correspond with our western Sundays. They were also observed in ancient China as days of rest for men as well as for the sun. Now we come to the squares for dates beginning with the first day (Chinese new year day), being a single horizontal line or dash in front of which (to the right) is a fancy character which can be freely translated into day, meaning day 1, day 2, day 3, being 1 dash, 2 dashes, and 3 dashes. Then comes the box-shaped character 4; the digits can be followed up to 10, which consists of a cross like a plus sign. This is the last numeral which has to be preceded with the character "day," it being assumed after that. For 11 we have a cross and a dash meaning 10 and 1 = 11, followed by 12 a cross and 2 dashes. By following this plan we arrive at 19, consisting of the cross and the Chinese digit 9. Thus we have reached 20, which is just the reverse of the Chinese 12, that is to say, we find two dashes followed by the cross. This means 2 times 10 = 20. When a small number precedes a large one, it is always a multiplier, but when it follows the larger number it is always added. Twenty-one usually consists of this same combination followed by a single dash, making it read 2 times 10 and 1 = 21. For convenience, however, a condensed form of 20, to be used from 21 to 29, has been devised, so that these numbers can be constructed with two characters instead of three. This abbreviated 20 consists of two vertical strokes with a horizontal dash across them at the middle and a small link at the bottom. This condensed form followed by Chinese digits 1 to 9 carries us up to 29. This number brings us up as far as the end of Chinese months, but as we will refer shortly to the 76th cycle of 60 years, it might be well to describe these numbers up to a higher figure. Thirty is three dashes followed by cross = 3 × 10. Thirty-one is a condensed form of 30 the same as 20, with an extra vertical stroke. This character followed by the digits 1 to 9 brings us from 31 to 39. Forty is square digit 4 followed by crosses 10 = 4 × 10. Now for 41 to 49 we are not permitted to use a condensed 40. Hence these numbers require three characters, consisting of digit 4 followed by cross 10 and these two followed by the digits 1 to 9. This formula is carried up unchanged to 99, when a special character comes in for 100, which when qualified by the digits and followed by numbers 1 to 99 brings us up in regular order to 999. A character for 1,000 is then brought in. By preceding it with the digits as multipliers followed by any

of the combinations below 1,000, it becomes just as easy to write a Chinese number up to 9,999 as it is to write it in Arabic, and very much easier than the Roman numerals. Before leaving the subject of Chinese numbers it should be said that it is just as permissible to write a Chinese number in a vertical line as in a horizontal one, but it must always be constructed and read from top down or from right to left. That is to say, the Chinese number 51 is the Chinese digit 5 followed by 10 and then 1, written down or toward the left. In either case it means $5 \times 10 + 1$.

Refer now to the 76th cycle, the long narrow cut. In the first column (the right-hand one) are arabic numbers for the 60 years of this cycle. In the next column are Chinese equivalents, which the reader can now write as easily as ours. The next two columns are the 10 stems and 12 branches, sometimes called the 10 celestial stems and 12 honorary branches, or the 10 mothers and 12 children. In older China the affinities of the 10 stems meant the 5 original elements of the universe—earth, metal, water, wood, and fire, and many other things too numerous to mention here. The 12 branches or 12 honorary characters or 12 children meant the 12 parts of a man; the 12 signs of the zodiac; the twelve great men; the 12 parts of a day (six for light and six for dark); the 12 months of the year; the 12 animals. There were also cycles of years based on this duodecimal plan which were given the names of animals as follows:

Rat or Mouse.	Ox or Bull.	Tiger.	Hare or Rabbit.	Dragon.	Serpent or Snake.
Horse.	Goat or Sheep.	Monkey or Ape.	Cock, Chicken, Rooster or Bird.	Dog.	Boar, Hog or Pig.

These animal names become synonymous with numbers. Hence a Chinaman or a Japanese will tell you he was born in dragon year or dog year. Clocks are still running which strike the hour of the rat or the horse. Expressions such as "before horse" or "after horse" meaning before noon or after noon or A. M. and P. M., are in use. "Full horse" was exact noon. In modern China, however, these signs of the stems and branches or mother and children have come to mean numbers only, 1 to 10 and 1 to 12. They still retain one-syllable names, the approximate sound of which is given in the two columns. You will notice that it takes six sets of stems to make a column of 60 and five sets of branches, and as these five and six sets overlap each other on a sort of slide-rule plan, no stem or branch meets more than once on the horizontal lines. This makes sixty different combinations or pairs of stem and branch characters, thus forming 60 two-syllable words, no two of which are alike. Thus the first year of this or any other sexagenary cycle of sixty becomes Kiah-Tsu; the 46th of the cycle just coming to a close is Ki Yu. The new year, the 47th, becomes Keng-Suh. The last syllable of it means dog. Hence the new year will be "dog year" on the cycle-of-12 plan.

The reader may get the impression that the Chinese calendar is so bad that it could hardly be worse. This is perhaps partly true, but what answer could we give an educated Chinaman if he asked us why we adopted his ancient seven days for a week or still use his months in their sadly confused form of 28, 29, 30, and 31 days in such an irregular order that we have to memorize a silly rhyme to know how many days are in a certain month? We could of course point with pride to the fact that Pope Gregory gave us a year which does not go wrong over a month, as the lunar one does, but less than a day.

The Chinese or Japanese calendar clock shown is drawn from fragmentary information and such odd parts as have come to the writer's notice. The hour, day, month, year and cycle are set to indicate the Chinese New Year as above mentioned. The small bent hand or pointer in the center indicates the hour of the rat (2 hours long), the center of which unit corresponds with our midnight. There are many interesting points regarding the clock proper that I would like to speak of here, but as the subject is calendars we will not depart now. The day begins and ends when the hand is at the bottom on this clock. Therefore we will assume that the last day of the 46th year of the 76th cycle has just departed and that the first day of the first month of the 47th year is moved into proper position. We look for the two small circles marked "1st month" and "1st child," giving us the double syllable name or number of the 1st day. Then at the top the two circles on either side of the month character we show movable characters, meaning first and small. That is to say this particular month has 29 days. The large ring containing the 12 branches has then moved one space, bringing the New Year animal name "Shu" into proper place at the bottom to read "Dog year" to those using the separate cycle of 12. But this large ring is an internal gear of 12 teeth or any multiple of 12 traveling in unison with another ring, which carries the 10 stems but with teeth on its outer edge in the ratio of 10 to 12 as compared with the internal gear. Therefore it takes six complete rotations of the stems to each five complete ones of the branches. It also follows that, as the stem ring has made 4 rotations and 7 spaces, it reads $4 \times 10 + 7 = 47$th year, or as the large ring of branches has gone three times around and 11 spaces, it reads $3 \times 12 + 11 = 47$ again. This brings the 7th stem Keng directly over the 11th branch SHU, and with these two single syllables made into a two-syllable word we have again 47 or Keng Shu, the present year.

The five pairs of stems and branches which are breaking company on the left show the past five years, and double-headed arrows indicate how these stems and branches change partners to mark the five coming years. The Chinese numeral on the left top corner of each space indicates the numeric equivalent of

76TH SEXAGENARY CYCLE COMPLETE.

OUR YEAR	CHINESE YEAR.	TEN STEMS	TWELVE BRANCHES.	CHINESE & ARABIC NUMERALS	
1864	KIAH-TSU	KIAH	TSU	一	1
1865	KIN-CHOU	YIN	CHOU	二	2
1866	PING-YIN	PING	YIN	三	3
1867	TING-MAO	TING	MAO	四	4
1868	WU-CHEN	WU	CHEN	五	5
1869	KI-SSU	KI	SSU	六	6
1870	KENG-WOO	KENG	WOO	七	7
1871	SIN-WEI	SIN	WEI	八	8
1872	SEN-SHEN	SEN	SHEN	九	9
1873	KWEI-YU	10 KWEI	YU	十	10
1874	KIAH SUH	KIAH	SUH	十一	11
1875	YIN-HAI	YIN	12 HAI	十二	12
1876	PING-TSU	PING	TSU	十三	13
1877	TING-CHOU	TING	CHOU	十四	14
1878	WU-YIN	WU	YIN	十五	15
1879	KI-MAO	KI	MAO	十六	16
1880	KENG-CHEN	KENG	CHEN	十七	17
1881	SIN-SSU	SIN	SSU	十八	18
1882	JEN-WOO	JEN	WOO	十九	19
1883	KWEI-WEI	10 KWEI	WEI	二十	20
1884	KIAH-SHEN	KIAH	SHEN	二十一	21
1885	YIN-YU	YIN	YU	二十二	22
1886	PING-SUH	PING	SUH	二十三	23
1887	TING-HAI	TING	12 HAI	二十四	24
1888	WU-TSU	WU	TSU	二十五	25
1889	KI-CHOW	KI	CHOW	二十六	26
1890	KENG-YIN	KENG	YIN	二十七	27
1891	SIN-MAO	SIN	MAO	二十八	28
1892	JEN-CHEN	JEN	CHEN	二十九	29
1893	KWEI-SUU	10 KWEI	SUU	三十	30
1894	KIAH-WOO	KIAH	WOO	三十一	31
1895	YIN-WEI	YIN	WEI	三十二	32
1896	PING-SHEN	PING	SHEN	三十三	33
1897	TING YU	TING	YU	三十四	34
1898	WU-SUH	WU	SUH	三十五	35
1899	KI-HAI	KI	12 HAI	三十六	36
1900	KENG-TSU	KENG	TSU	三十七	37
1901	SIN-CHOU	SIN	CHOU	三十八	38
1902	JEN-YIN	JEN	YIN	三十九	39
1903	KWEI-MAO	10 KWEI	MAO	四十	40
1904	KIAH-CHEN	KIAH	CHEN	四十一	41
1905	YIN-SUU	YIN	SUU	四十二	42
1906	PING-WOO	PING	WOO	四十三	43
1907	TING-WEI	TING	WEI	四十四	44
1908	WU-SHEN	WU	SHEN	四十五	45
1909	KI-YU	KI	YU	四十六	46
1910	KENG-SUH	KENG	SUH	四十七	47
1911	SIN-HAI	SIN	12 HAI	四十八	48
1912	JEN-TSU	JEN	TSU	四十九	49
1913	KWEI-CHOU	10 KWEI	CHOU	五十	50
1914	KIAH-YIN	KIAH	YIN	五十一	51
1915	YIN-MAO	YIN	MAO	五十二	52
1916	PING-CHEN	PING	CHEN	五十三	53
1917	TING-SSU	TING	SSU	五十四	54
1918	WU-WOO	WU	WOO	五十五	55
1919	KI-WEI	KI	WEI	五十六	56
1920	KENG-SHEN	KENG	SHEN	五十七	57
1921	SIN-YU	SIN	YU	五十八	58
1922	JEN-SUH	JEN	SUH	五十九	59
1923	KWEI-HAI	10 KWEI	12 HAI	六十	60

COMPLETE SEXAGENARY CYCLE WITH TRANSLATIONS.

each stem and branch when they are used separately. They are geared together here, however, to get the sexagenary period. No odd and even branch or stem ever coincide, but always even and even or odd and odd. In other words, the top stem always jumps over the top branch to select its new partner. When these 10 stems and 12 branches complete their 60 different partnerships, the 76th cycle of 60 years will be complete. Then the horizontal wheel at bottom will move to the next cycle, bringing the Chinese number 77 on the center line, or, as it reads by literal translation, 7 times 10 and 7. This same order will continue up to the 120th cycle or $2 \times 60 \times 60 = 7{,}200$ years from the beginning of this system. This whole proceeding of course depends on keeping the machine going and attending to the intercalary connections to keep seasons from rotating. To repeat, let us say that this calendar reads as it now appears in the illustration *1st Hour of 1st Day of 1st month of 29 days of the 57th year of the 76th cycle of 60 years*, which is also the 2,461st of Confucius or second year of Emperor Hsaun Tung or the 4,547th year by the sexagenary system or 4,607 from the time the Yellow Emperor Hwang Ti ascended the throne. It is also most nearly associated with our year 1910.

Refer to the annular space between the clock dial and stem ring. This space has five spokes which divide the world into the five original elements (as the Chinese supposed) "Earth," "Metal," "Water," "Word," and "Fire." The affinities or extremes of earth are *Wu*, a hill or mountain, and *Ki*, a level field or plain. Metal extremes are *Keng*, an implement of war and sin, a cauldron, an implement of peace. Water was of two kinds, rough billows or waves and placid streams. They are *Jen* and *Kwei*. Wood consisted of *Kiah*, a heavy tree, and *Yin*, light bamboo. Fire was made up of *Ping*, a sort of flame, and *Ting*, meaning light. These ten stems are the result of the *Yang* and *Yin*, or positive and negative, or extremes of the five elements.

The twelve stems are frequently used as the 120 minute hours of Japan. No. 1 or "Rat" is midnight (after 60 minutes of it are used). The sixth stem or Horse therefore becomes noon, but not till the middle has been reached. That is to say the first half of Horse is still forenoon, the latter half is afternoon, and the exact middle is full horse or true horse, meaning exact noon. When these 12 stems are used under the proper radical to represent the stars, "Rat" becomes Tarus and Horse Scorpio. When we come to the twenty-eight stellar mansions, however, the stems and branches are laid aside for twenty-eight characters, which Dr. Carus in his "Chinese Thought" supposes to be an ancient form of the lunation before it was properly measured. I am more inclined to think that it was a sidereal lunation taken on the broad view of the universe, making a year of 13—28 day months or 364 days and requiring only one intercalary day and two every fourth year.

WHAT IS GENETICS?

We are constantly confronted with questions in which we have to think, not only of the advantage and happiness of those alive at the present moment, but also of these not yet born who will succeed us on the earth. The decision of these questions is one of the most important and burning subjects which can be put before us. They often crop up in legislation, and yet we are quite unable to answer them because of the very little knowledge we possess of the laws which govern the transmission of characters from generation to generation.

The interests of future generations often appear to be in conflict with the immediate pleasure and happiness of the living, and we are confronted with the question whether we ought to give way to our own humane and benevolent feelings or whether we ought to set our teeth and deal ruthlessly with a number of people who must appeal to our pity, lest by saving them from elimination we should bring about an increase in the number of people who are unable to hold their own, and so weaken the nation and increase for the next generation the difficulties which we set out to cure. We do not pronounce any judgment on these questions; we merely wish to emphasize the immense, the transcendent importance, from the human point of view, of the investigations which the study of the question of evolution has caused biologists to carry out into that most difficult of all subjects, heredity, and of obtaining clear ideas upon the subject. These are elementary examples, and they might be largely added to from other branches of zoology, such as entomology, marine fauna, and physiology—of the great practical achievements which have followed from the recognition of the fact, possibly appreciated in some ancient civilizations, but in modern times first understood by Bacon and his compeers, that natural phenomena are in themselves, and without reference to immediate utility, proper subjects of man's inquiry, and that all progress must be based on their thorough and accurate investigation.

A consideration of the mechanical principles involved in valve construction, and the duty required lead to the conclusion, says a contemporary, that electrically operated stop-valves offer many advantages, as compared with the hand-operated type. They can be operated from any point, often permit a simpler laying out of piping and, in time of accident, make it possible to shut off a valve that might otherwise be inaccessible on account of fire, escape of steam, etc. The stopping and starting of large units upon short notice is expedited by motor-driven valves for the large exhaust piping, and when installed between the boilers and steam header, or the header and the engine, and between sections of the leader, they enable any break in the piping to be isolated at once, or any other trouble checked by closing switches which may be situated a safe distance away from the piping.

INSECT PESTS IN AGRICULTURE.

THEIR PRACTICAL UTILIZATION.

THE ill repute which attaches to insects in general is justified by the ravages committed by the many insect enemies of flowers, vegetables, grain, fruit and forest trees. These marauders, however, are themselves the prey of various carnivorous and parasitic insects. This civil war in the insect world results to man's advantage, for the insectivorous insects are both numerous and prolific. Their methods of attack vary with the species. Some, like the ladybird, simply capture and devour their prey, while others lay their eggs in or upon the larvæ and eggs of their victims.

Fig. 1.—1, Larva of Cabbage Moth Opened to Show Parasitic Larvæ of Ichneumon Fly; 2, Full-grown Parasitic Larvæ Emerging from the Skin of their Dead Host and Spinning Cocoons Beside it; 3, Ichneumon Fly. (Greatly Magnified.)

Tetrastichus, for example, pierces the eggs of the elm gall insect and prevents their hatching, and some ichneumon flies deposit their eggs in the bodies of caterpillars which are "eaten alive" by the larvæ which issue from those eggs.

For the purpose of destroying injurious insects the infested plants, branches, leaves or fruit are often destroyed also. Paul Marshal, an eminent authority on this subject and director of the French institute for combating injurious insects, has pointed out that by this practice we also destroy our natural allies, the insect parasites. For example, farmers have been advised to remove the stubble from grain fields in order to destroy the gall fly (*Cecidomyia*), but the flies have disappeared long before harvest time, while the stubble may still contain parasites which would have attacked the flies of the next season. A similar example is afforded by *Diplosis*, an insect which lives in the grain kernel. Kieffer has proved that the practice

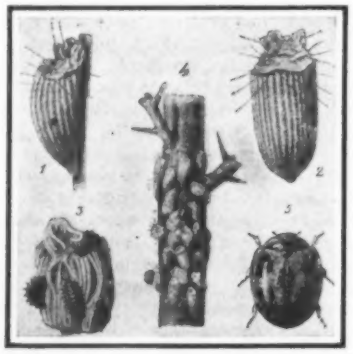


Fig. 2.—1 and 2, Scale Insects (*Icerya*); 3, Scale Insect with Parasitic Larvæ of *Novius*; 4, *Novius* Depositing Eggs on Scale Insects; 5, *Novius*. (Magnified.)

of burning the threshed straw defeats its own object, for the pupæ normally lie buried in the earth, and only pupæ that have been injured by parasites remain in the straw. Burning the straw, therefore, merely destroys the enemies of the injurious insect. Decaux, having observed many ichneumon flies emerging from buds of apple branches, which had been singed to destroy the apple moth, suggested keeping the buds in covered vessels until all the ichneumon flies should come out. In this way he secured and released, from five barrels of singed buds, about 250,000 ichneumon flies, and incidentally destroyed more than 1,000 apple moths. Beriese kept larvæ of *Cochylis*, with their parasites, through the pupal stage in boxes provided with openings large enough to permit the parasites to escape, but too small to be traversed by the *Cochylis* butterflies. In the war against the destructive San José scale and other species of *Aspidotus* it is customary to cut off the infested branches in winter. No other measures are required, for, as the scale insects feed only on living plants and are incapable of motion, they starve on the cut branches, while the parasites which feed upon them, fly back to the orchard after pupation. The utilization of "entomophagous," or insectivorous insects, is little practised in Europe, but in America, where the subject has been far more thoroughly studied, parasites have been imported from the native countries of plants infested with injurious insects.

A remarkable instance is that of a scale insect, introduced from Australia, which nearly destroyed the orange and lemon plantations of California. A commission was sent to Australia to search for parasites of this scale insect. A parasite was found and 100 specimens were brought to California, where they multiplied so rapidly that in the following year 10,000 parasites were distributed among the nurseries, and in a year and a half the scale was almost annihilated and the plantations were saved.

In employing parasites for the destruction of injurious insects, the method of procedure necessarily varies with the species which is the object of attack. In America, for the purpose of combating the Liparid moths, which are so destructive of fruit and forest trees, hundreds of thousands of nests of caterpillars of *Liparis chrysorrhœa* are sent, each winter, to a laboratory in Boston, which is devoted to the propagation

Fig. 3.—1, Twig Infested with Scale Insect (Aspidiotus); 2, Aspidiotus Separated from Its Scale, and Pupa of Its Parasite Aphelinus; 3, Aphelinus. (Greatly Magnified.)

and study of parasites of moths. The parasites are reared in boxes provided with glass windows through which the life processes and habits of the insects can be observed, and glass tubes, with their outer ends plugged with cotton, are inserted in openings in one side of the box (Fig. 5). The parasitic insects, after pupation, seek the light and fly into the glass tubes, where they can be examined with a magnifying glass. These parasitic insects are sometimes found to be infested with parasites of their own. In this case, the insects and their parasites, or the latter alone, are destroyed. The insects which are free from parasites are set at liberty or kept for breeding. In order to prevent the dissemination of the non-indigenous hyperparasites which occasionally accompany parasitic insects sent from foreign countries the rooms are kept carefully closed and are provided with double doors. When the useful parasitic insects leave the breeding cages they are usually not set completely at liberty,

Fig. 4.—1, The Parasite Encyrtus, and Egg Clusters of Spinner Moth; 2, The Parasite Depositing Its Eggs in Those of the Spinner Moth; 3, Larva of Spinner Moth Containing Eggs of Parasite.

but are confined either in large cages of fine wire gauze built around and over trees which are greatly infested by injurious insects, or in smaller cages constructed over shrubs, where each parasite species can be propagated separately. In this way the development and increase of each species can be observed, as in the study of bacteria by means of pure cultures.

German entomologists have not quite reached the American standpoint. Prof. Eckstein, for example, writes: "The usefulness of parasites is confined to maintaining the general balance in nature. They have

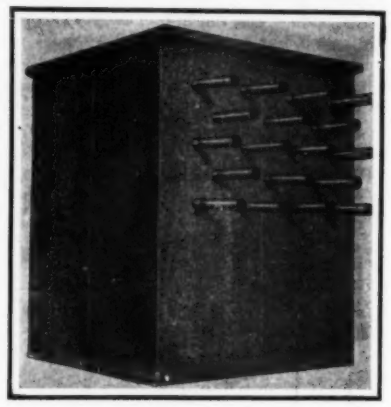


Fig. 5.—Breeding Cage for Parasitic Insects.

no economical value, for they do not abandon their hosts until the latter have reached the pupa stage, after eating their fill, and the larvæ which escape the parasites suffice for the propagation of the injurious species."—Umschau.

FLAME AND OZONE.

THOSE who are familiar with test-tube experiments in the chemical laboratory may have observed that when a tube containing cold water is placed in the flame of the Bunsen burner, or, better still, in the fierce flame of the Kern burner, a smell strongly resembling ozone is noticeable when the tube is removed quickly from the flame. When the liquid gets warm the phenomenon ceases. The subject has been studied more recently with the view of obtaining definite results, and there appears to be little doubt that ozone is invariably present in flames. In the case of the hydrogen flame the presence of ozone is proved by the action of the flame on silver. A vigorous current of hydrogen is ignited at a narrow jet and only the point

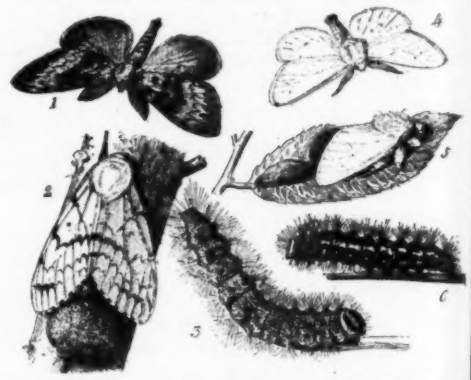


Fig. 6.—1, Male Sponge Spinner; 2, Female Sponge Spinner; 3, Larva of Sponge Spinner; 4, Male Golden Tail; 5, Female Golden Tail, Laying Eggs; 6, Larva Golden Tail.

of the flame is used to touch the silver. A black film of oxide is produced which is most intense where the silver is in contact with the hottest zone of the flame. Ozone is not found outside the flame for the simple reason that it breaks down in its passage through the zones of relatively low temperature. Therefore, from a practical point of view, intense flames would hardly serve the purpose of producing ozone, nor can it be supposed that the presence of intense flames in a room can be a source of ozone sufficient to be a means of removing the impurities of the air by oxidation. The ozone and in some cases hydrogen peroxide are merely an effect of the high temperatures of the inner zones of a very hot flame. In some cases the ozone may escape being decomposed, as by blowing a strong current of air through a tube into the flame of an ordinary Bunsen burner. It is an interesting fact that ozone is produced by ultra-violet rays, and the hot flame of an atmospheric burner working under perfect conditions is rich in these rays. The ultra-violet rays are probably the source of ozone in nature, the rays themselves, of course, owing their origin to the sun.—Lancet.

COMBUSTION AND EXPLOSION.—II.*

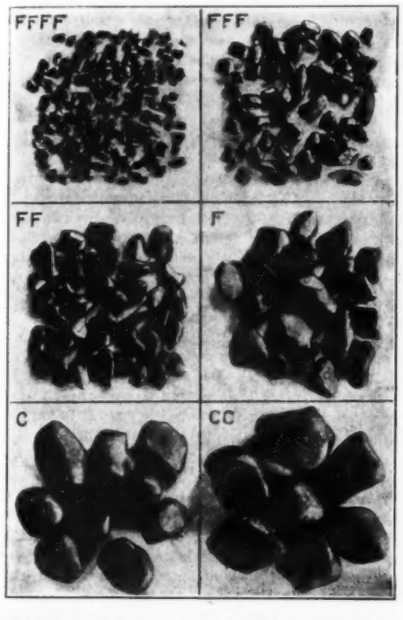
A PRIMER ON EXPLOSIVES FOR COAL MINERS.

BY C. E. MUNROE AND CLARENCE HALL.

Concluded from Supplement No. 1780, Page 106.

AS MAY be inferred from what has already been said, a large number of substances are known and used as explosives. The one longest known and used is gunpowder, which has certainly been used since early in the fourteenth century. This is made by intimately mixing 75 parts of India saltpeter (potassium nitrate) with 15 parts of charcoal and 10 parts of sulphur. Each of these ingredients is ground to a fine powder, and then they are ground together while moistened with water, in the proportions given, until the mixing is complete. The material is pressed into cakes, which are then broken up into grains, which are dried, glazed by rubbing, and sorted by the aid of sieves into the various sizes.

Formerly this India saltpeter powder was used both in guns and in blasting, and while to-day some of it is used in blasting, the larger part of what is used in this country under the name of black blasting powder is composed of 73 parts of Chile saltpeter (sodium nitrate or nitrate of soda), 16 parts of charcoal, and 11 parts of sulphur. This black blasting powder is made



GRAINS OF BLACK BLASTING POWDER.

in a manner similar to that described for gunpowder, but less time is spent in making the mixture, and the charcoal is usually obtained from coarse-grained woods. The Chile saltpeter will supply more oxygen, and supply it more easily, than the India saltpeter, and therefore is a better and cheaper oxidizing agent, but the Chile saltpeter is not used in the manufacture of gunpowder because when it is exposed to moist air it takes up water by absorption from the air and becomes wet, and powders or other explosives in which this Chile saltpeter (nitrate of soda) is used likewise take up moisture when exposed to the air and become damp, so that it is difficult, and sometimes impossible, to set fire to them. As gunpowder for use in guns and firearms must often be kept for a great many years, and yet always be in such condition that it can be fired at any moment with certainty, this property of absorbing moisture from the air makes the nitrate of soda unfit for use in gunpowder; but blasting powder is not expected to be stored for years, and in magazines at mines it is quite possible to store it for a while so as to protect it from exposure to damp air. Besides, by proper management it is possible to obtain this blasting powder fresh from the manufacturer and use it promptly while in that condition, hence advantage may be taken, for economic use, of the superior efficiency and cheapness of the nitrate of soda in the manufacture of blasting powders if we keep them dry.

Black blasting powder comes into the market in the form of grains whose edges have been rounded off by rubbing together in a revolving barrel and which are usually coated on the surface, or glazed, as it is termed, with graphite, or black lead. The object in rounding and glazing the grains is to render them free running, and the glazing also serves to delay somewhat the taking up of moisture from the air by the grains.

The powder is divided into grades according to the size of grains, as separated and collected by sieves of different sizes of openings. The sizes most usually offered for sale are called CC, C, F, FF, FFF, and FFFF. Of these, CC represents the largest grains, about one-half inch in diameter, and FFFF represents the smallest grains, about one-sixteenth inch in diameter. The relation between the letters designating the sizes of the powder and the sieves by which the different sizes are separated is shown in the following table:

Relation Between Sizes of Black Blasting Powder and Separating Sieves.

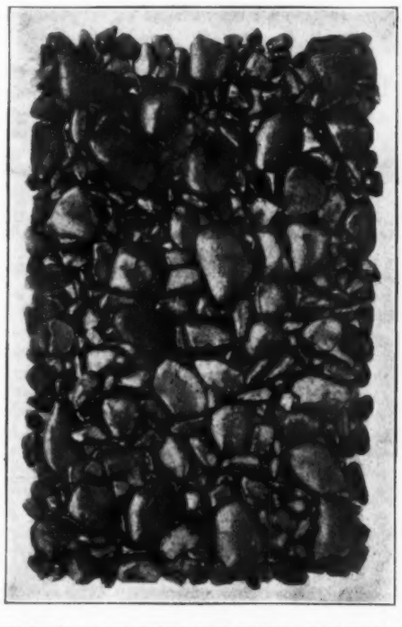
Size of Grains.	Diameter of Round Holes in Screens through Which Grains Pass.	Diameter of Round Holes in Screens on Which Grains Collect.
CC	1/2 inch	2/5 inch
C	2/5 inch	1/3 inch
F	1/3 inch	1/5 inch
FF	1/5 inch	1/8 inch
FFF	1/8 inch	1/16 inch
FFFF	1/16 inch	1/28 inch*

To get the best results in the use of this powder in blasting, the grains should be of uniform size, so that the miner, having determined the best size of charge, may have no difficulty in repeating it. Unfortunately, not enough care is taken in separating the grains into the different sizes, and powders have appeared in the market in which a considerable number of different sizes of grains were mixed together, so that the miner has obtained quite different results from his different shots in the same mine of coal with the same grade of powder. Moreover, where large and small grains of powder are mixed in a charge, the fine grains, which burn freely, may produce, in burning, enough pressure to throw the large grains out into the mine where they can set the gas and dust afire. This makes such a mixture of grains a dangerous one in use.

It has already been said that many other substances besides India saltpeter (potassium nitrate) and Chile saltpeter (sodium nitrate) are known which contain oxygen in such quantity and in such manner that they may be used as the oxidizing agents in forming explosives. Among these is the substance known as potassium chlorate. More than one hundred years ago an eminent French chemist showed that when it was mixed with combustible substances a most powerful explosive was produced but, unfortunately, this mixture was found to be so sensitive to friction, blows, and heat as to endanger the lives of those who sought to handle and use it. Many of the mixtures produced with potassium chlorate are so easy to prepare and explode with such violence that a great many persons have been tempted to make them, but until recently all those that have been devised have been rejected as unfit for use because they were liable to destroy those who attempted to make use of them. It is found, however, that when dry and finely ground potassium chlorate is mixed with a body like starch, and with oil and other substances, an explosive is produced that is fairly safe to handle. Mixtures of this nature have met with some use in Europe.

Attention has also been called to the fact that when purified dry cotton is immersed in nitric acid in the proper manner it is changed into an explosive substance through reaction with the nitric acid. When we withdraw the fibrous cotton from the nitric acid, wash it thoroughly to remove any acid that sticks to it, and then carefully dry it at a low temperature, the cotton appears unchanged to the eye, even when examined most carefully. It has, however, become a little harsh to the touch. When rubbed, it becomes electrified so that it sticks to the fingers, and when a flame is applied to it, it flashes off with great rapidity. In practice, a mixture of sulphuric acid is used with the nitric acid in nitrating the cotton. By varying the strength and the proportions of the nitric and sulphuric acids, their temperature when the cotton is dipped in them, and the length of time that the cotton is in them, we can get a number of different products varying in the rate at which they will burn and in the degree to which they are soluble in various solvents; but every such product results from the replacement of more or less of the element known as hydrogen, which was present in the cotton, by nitrogen and oxygen (indicated by the formula NO_2), which came from the nitric acid. Such a product, obtained by the action of the nitric acid on the cotton, will take fire and burn the more easily the greater the number of NO_2 groups that have replaced hydrogen in the cotton. We may, for convenience, divide these various products into two classes. Those which contain the fewer of these NO_2 groups are called pyroxylin, or soluble nitrocellulose, or collodion cotton, and those which contain the greater number of the NO_2 groups are known as gun cotton. In the manufacture of gun cotton the very strongest nitric and sulphuric acids are used. After the product has been washed so as to remove most of the acid sticking to it, it is pulped while wet into a fine powder in a machine such as is used in pulping paper stock, and when the gun cotton has been washed in this powdered condition so as to remove the last traces of acid, it is molded into blocks or sticks and is used as an explosive in that form.

Nitroglycerin is prepared by slowly running glycerin into a mixture of the strongest nitric and sulphuric



MIXTURE OF DIFFERENT-SIZED GRAINS OF BLACK BLASTING POWDER.

acids, the whole being stirred and kept cool during the process of mixing. The reaction which takes place between the glycerin and the nitric acid is similar to that which takes place with the cotton. As a result of the reaction, NO_2 groups from the nitric acid replace hydrogen in the glycerin, and the mild, sweet, harmless glycerin is thereby changed into the powerful and dangerous explosive nitroglycerin. Nitroglycerin is a rather dense, oil-like liquid. When pure it is colorless, but as it appears in the market it is usually pale yellow. It is somewhat poisonous, and one can be poisoned by it not only through the mouth but also by breathing its vapors or by allowing the liquid to touch the skin. A drop of it touching the tip of the finger will usually soon produce a violent headache. Fortunately, most persons lose their sensitiveness to poisoning after repeated contact, so that they cease to have the headache, but it would still be dangerous for these persons to get any of the nitroglycerin into the mouth. Nitroglycerin may freeze after some exposure to a temperature of 52 deg. F. and it must be thawed before it can be properly used as an explosive.

Being a liquid, nitroglycerin is especially dangerous for ordinary use, because it may escape from the cans or other vessels in which it is carried or stored and run off to considerable distances, so as to increase the chances of accidental explosion by a blow, or friction, or heat and also because it may, when placed in a bore hole, leak out into crevices or seams in the rock, and when fired give most undesirable results. In fact, during the middle of the last century, when it was offered for use, so many accidents occurred that many countries, by law, forbade its use or manufacture. We can, how-

* Abstracted from Bulletin 423, published by the United States Geological Survey.

* Square holes.

ever, prevent a liquid from flowing about by absorbing it in a porous body, like a sponge. This has been done with nitroglycerin, and the product is called dynamite. Dynamite consists of nitroglycerin absorbed in a solid body called the "dope." There are many dynamites. One of the earliest known and used was made by absorbing the nitroglycerin in powdered "rotten stone." As the "rotten stone" could neither burn nor explode, it was called an inactive dope, and there are several varieties of dynamites with inactive dopes. On the other hand, nitroglycerin may be absorbed in gunpowder. As the gunpowder explodes, as well as the nitroglycerin, when the dynamite is fired, the gunpowder is called an active dope. There are a large number of dynamites made with active dopes, and with varying percentages of nitroglycerin. The standard straight dynamite used at the Pittsburg testing station may be taken as an example of a dynamite with an active dope. It consists of the following:

Composition of Standard Straight Dynamite.

	Per cent.
Nitroglycerin	40
Nitrate of sodium	44
Wood pulp	15
Calcium carbonate	1
	100

Since it is a liquid, nitroglycerin, like other liquids, acts as a solvent, and it has been found that under certain conditions it can dissolve soluble nitrocellulose, and that the mixture thus formed will set to a jelly-like mass. In this way, or sometimes by the use of other solvents also, the substance known as explosive gelatin is formed, a substance that in some respects is regarded as the most nearly "ideal" explosive. However, it is too powerful for ordinary use in blasting, and it is therefore diluted by mixing it with a dope, such as the nitrate of soda and wood pulp used in straight dynamite. The mixture so formed is known as gelatin dynamite.

It has already been said that nitroglycerin when exposed to ordinary winter temperatures will freeze. Dynamite, explosive gelatin, and gelatin dynamite will also freeze, because all of them contain nitroglycerin, and, like nitroglycerin, all of these substances should be properly thawed before any attempt is made to use them.

Each of these substances is put upon the market in the form of sticks or cartridges, which are made by wrapping up cylinders of the material in paper. The wrappers for dynamite and gelatin dynamite are paraffined to protect them from the action of water and the moisture in the air, because they contain nitrate of soda and hence may absorb moisture and become spoiled, and develop new sources of danger in handling and use. These sticks usually vary in size from seven-eighths inch to 2½ inches in diameter, and they are usually 8 inches long. They are usually packed in cases containing 50 pounds each. The mark "This side up," or a design on the top of the case, shows the position in which the cartridges are packed. The cases should always be placed so that the cartridges lie on their sides, and they do lie so when the cases are stored with their top sides up.

For use in coal mines it is suggested that the explosive be packed in cases or cartons containing the weight which the law of the district permits being taken into the mine.

Besides cotton and glycerin, there are a large number of substances, such as sugar and starch, that are chemically related to cotton and glycerin and through the action of nitric acid, particularly in the presence of sulphuric acid, give rise to explosive substances. Many of these have been produced, but so-called nitrostarch is the only one that seems to have any commercial importance. During the last ten years this has attracted some attention, and it has been offered for use both in this country and in Europe. It is a finely powdered substance like starch itself, but it does not need, as starch does, to be suspended in the air in order to explode on ignition, because even when in a pile it will burn with great rapidity if set afire, and through the action of a detonator it explodes with great violence. It is not yet used by itself, but is used as a component in various explosive mixtures, particularly dynamites.

Attention has been called to the use of potassium nitrate and sodium nitrate in the manufacture of explosives. In recent years another nitrate, formed by the union of ammonia with nitric acid and known as ammonium nitrate, has come to be somewhat largely used. It has been used in this country for more than a quarter of a century in the manufacture of some dynamites, taking the place of sodium nitrate, and having the advantage over it that on explosion it goes completely into gases, but it has come to be used in Europe in the manufacture of special explosives for use in coal mines, for the reason that on explosion it forms a large amount of water, and this lowers the temperature of all the products of the explosion. In the making of several of these ammonium-nitrate powders, various substances obtained from coal tar, which generally have been acted upon by nitric acid, are mixed with the ammonium nitrate.

The substances derived from the coal tar, after having been acted upon by the nitric acid, are known as nitro-substitution compounds. One of the substances obtained from coal tar which is perhaps best and longest known is carbolic acid, and when this reacts with strong nitric acid it gives us the nitro-substitution compound known as picric acid. Other substances obtained from coal tar that are pretty well known are benzene, toluene, and naphthalene. When these are acted upon by nitric acid we obtain from them the nitro-substitution compounds known as nitrobenzene, nitrotoluene, and nitronaphthalene. These are but a few of the many substances that may be obtained from coal tar and furnish, through the action of nitric acid upon them, nitro-substitution compounds. All the nitro-substitution compounds will form explosives when mixed with oxidizing agents such as ammonium nitrate, or other nitrates, or chlorates, and many explosives have been made from such mixtures. Moreover, these nitro-substitution compounds have been used as components of dynamites, particularly because they lower the freezing point of the nitroglycerin in the dynamites.

The nitro-substitution compounds are so called because the NO_2 groups in them, obtained from the nitric acid, are directly connected to the carbon atoms in the original material, replacing hydrogen atoms; whereas in gun cotton, nitroglycerin, and bodies of that sort, the NO_2 groups are linked to the carbon atoms of the original substance by means of atoms of oxygen. The nitro-substitution compounds are usually yellowish to red crystalline solids, but as most of these solids are easily melted, they are often sent out in compact masses. A few of them are liquids at ordinary temperatures, and they have a marked aromatic odor. Some of these substances are poisonous. Great care should be taken in handling all of them, and one should especially avoid breathing their vapors.

As has been stated above, the most common fulminates are produced by dissolving a metal, such as mercury, in a strong nitric acid, and pouring the solution into common alcohol. When the proportions used are correct and the operation is carried out in a proper manner, after an apparently violent reaction there will be produced a mass of fine, gray crystals that look quite alike, and this is known as fulminate of mercury, or mercury fulminate. The crystalline powder thus produced is washed with water to free it from acids, and because of its extreme sensitiveness it is kept soaked with water until desired for use. It is principally used in loading blasting caps or detonators, and for this purpose the water may be removed from it by alcohol and it may be loaded into the copper capsules while wet with alcohol, but it should be always borne in mind that this mercury fulminate, even when thoroughly soaked with or sunk under water or alcohol, will explode with tremendous violence if only a small amount of the dry fulminate be exploded while touching it, or very near it. Hence extreme precautions should always be taken with mercury fulminate, whether the substance be wet or dry.

The manufacture of explosives is by no means simple. Unless all the materials are of the proper kind and in the proper condition, and they are used in the proper order, in the proper manner, with the proper tools and vessels, and with all the proper precautions at each stage of the operation, the manufacture is a very dangerous thing to undertake, and it is very foolish for anyone to undertake it by himself.

NEW USES OF PAPER.

PEOPLE in general have no idea of the vast number of substances which paper has the power of absorbing, or of the importance which this unique capacity for absorption possesses for the paper-making and other industries. The fact that unsized paper readily absorbs liquids is familiar to everyone through his experience with blotting paper, but that the absorbing power of paper is almost unlimited and is not confined to liquids, but includes solids and gases, is a fact little known and little utilized. Yet there is scarcely one manufacturing industry which could not derive some advantage from the employment of paper, to which the most diverse and opposite properties can be given with the aid of this remarkable power of absorption.

For example, paper could be used with advantage, in place of celluloid, in many cases. Celluloid is highly valued for its many-sidedness. It is transparent and flexible in the form of photograph films and opaque, hard and rigid in the form of imitation ivory. It can be pressed, cut, turned, and worked in many other ways. All of these things can be done with paper, which can also, unlike celluloid, be made incombustible. For years an incombustible substitute for celluloid has been sought by hundreds of chemists. The only uninflammable substitute yet discovered is the substance called cellit, which is too expensive for practical use. Inflammable moving-picture films are especially dangerous and have caused many fires, owing to the concentration of a powerful beam of light and heat upon the film. Hence various safety appliances have been introduced, but it has not occurred to anyone to substitute transparent fireproof paper for the very inflammable celluloid. Yet a German patent was issued years ago for a process of making transparent paper lantern slides, which could be easily adapted to the manufacture of moving-picture films and would greatly lessen the danger of fire, as even paper which has not been fireproofed is far less inflammable than celluloid. Transparent paper, however, can be made absolutely fireproof, without impairing its transparency, by coating it with a thin film of waterglass.

The great value of the capacity of paper to absorb solids may be illustrated by another example. The most essential ingredient of the majority of filters consists of finely-divided charcoal, which retains the solid particles suspended in the liquid which is to be filtered. In many cases it is very difficult to obtain pulverized charcoal of the requisite fineness and other qualities. L. Pierucci, of Pisa, has met this difficulty by impregnating paper with charcoal powder. Paper treated in this way is very different from ordinary filter paper. It possesses the properties characteristic of charcoal filters, and it is also available for the filtration of liquids which attack common filter paper. Moreover, its high carbon content makes it a good conductor of electricity, and this property can be utilized in the construction of electrical apparatus.

In the electro-technical field the contradictory properties which may be conferred upon paper by means of its power of absorption are strikingly illustrated, for while paper is made a good electrical conductor by impregnating it with carbon, its conductivity can be entirely destroyed by saturating it with some other substances. Hackethal has constructed paper insulation for electric wires, which is permanently waterproof and very little affected by acids. The wire is wrapped in a special manner, with paper impregnated with suitable substances.

The absorbing power of paper is beginning to be utilized in the protection of various objects from water and fire. Paper can be made waterproof by saturating it with oil, or with resins and tar. Tarred paper is now used, to some extent, for the purpose of making boats watertight. In this way the necessity of tarring the entire boat is avoided and a better result is obtained. In tarring boats with a brush it is difficult to avoid the formation of bubbles, and when these bubbles break the wood is laid bare, so that the effect of the tarring is doubtful. In a process of fireproofing which has recently been introduced, in America, the objects are first covered with paper, fastened by means of a suitable adhesive, to a thickness of 1/10 inch or more. A paste, consisting of wood pulp and silica mixed with hemp or other fibrous material, is applied to the paper covering and, after drying, the surface is painted with a pigment mixed with a solution of waterglass. According to report, the coating formed in this manner does not peel off, even at a bright red heat—a property which is due largely to the impregnation of the paper with various substances before it is applied to the object. It is interesting to note that this latest application of the absorbent power of paper is very old in principle. The first volume of the Chemische Annalen, published in 1788, contains a description of a variety of paper, called "stone paper," which was prepared by Faxe for fireproofing the interior of buildings and ships.

A systematic and thorough investigation of the capacity of paper to absorb substances of various kinds, and a study of the properties of the products thus obtained, would doubtless be followed by many other applications of impregnated paper.—Umschau.

Even those who are aware of the immense value of pure research forget the fact that the aptitude for scientific investigation is as rare as the gift of poetry, to which in many respects it is allied, for both are creative gifts, rare and precious. They forget that it is impossible to ascertain without trial whether a man possess it or not, and that this trial can only be made when he has passed his student days and looks to support himself by his own exertions. To provide for this support money is needed, and studentships must be established in considerable numbers, from the holders of which those who show that they possess the gift of research can be selected and promoted to higher posts in which their gift can find full opportunity; but we want more than this—we want compensation for those whom we have encouraged to make the trial and who have failed to show that they possess the gift, and an outlet by which they can emerge and find work in practical life.

THE ORIGIN OF STELLAR SYSTEMS.

PROF. SEE'S RESEARCHES.

Soon the second volume of Prof. T. J. J. See's "Researches on the Evolution of the Stellar Systems" will appear. The work deals with a subject which has engaged the uninterrupted attention of the author for a quarter of a century; but it is chiefly within the past two years that he has succeeded in making the remarkable discoveries recently made public through the columns of the Astronomische Nachrichten. These have given a new aspect to the whole science of cosmogony, and have consisted in the development of the Capture theory, which has awakened profound interest throughout the scientific world.

Heretofore the problems of cosmogony have been considered well-nigh hopeless if not entirely insoluble. It is barely three years since the late Prof. Newcomb, one of the greatest astronomers of modern times, declared (in Popular Astronomy for November, 1906, p. 572) that he "still retained a little incredulity as to our power, in the present state of science, to reach even a high degree of probability in Cosmogony." In view of the false premises underlying all the reasoning since the time of Laplace, and the resulting failure of many eminent investigators who attempted to solve the problem, such incredulity is not remarkable.

Prof. See seeks to prove that the solar system was formed from a spiral nebula internally devoid of hydrostatic pressure, and therefore the planets have not been detached from the sun by rotation, as held by Laplace, but have been captured and added on from the outer parts of the nebula, and are therefore in no sense of the word children of the sun, as has been generally held for more than a century. The satellites likewise have been captured by their several planets, and not one of them detached by rotation from the central bodies which now govern their motions. Accordingly they are not, as we have so long been taught, children of the planets and grandchildren of the sun, but were originally independent planets moving in regular elliptical orbits about the central mass of our system, and were subsequently captured by the several planets about which they now revolve as satellites.

Our moon, likewise, was originally a planet which neared the earth and was finally captured and made a satellite. It was no part of the terrestrial globe detached by rapid rotation, as has been generally believed since the time of Anaxagoras, B. C. 500-428, and more recently taught by Laplace, Lord Kelvin, Sir George Darwin, Poincaré, Pickering, and other eminent writers.

The planetoids are the surviving remnants of millions of small planets with which our solar nebula was originally filled. At one time they extended over the whole planetary system, but most of them have at length been swallowed up by colliding with the larger bodies, and those which survive have been thrown mainly within the orbit of Jupiter.

The rotations of the planets on their axes have been produced by the capture and absorption of these small bodies, which may be called either asteroids or satellites.

As the satellites have all been captured, but were once independent planets, it will not seem strange that a few of them have retrograde motions; the capture theory explains this in a simple and easy manner, and it is in accord with the latest researches on the celebrated problem of three bodies, the treatment of which has been much improved by Jacobi, Hill, Poincaré, Darwin, and other mathematicians.

As the planetary rotations are due to the capture and absorption of satellites, theory shows that the larger planets, as Jupiter and Saturn, ought to rotate most rapidly. This is in accordance with observation, and the nature of the cause at work shows that the earth never could have rotated much if any more rapidly than at present.

The theories long current in geology and astronomy that the earth once rotated in two or three hours, so rapidly that it threw off a layer of peripheral matter now collected into the moon, are held to be quite devoid of foundation. The effect of this advance will be to show that the globe never was highly oblate, and to correct the theories of geology.

The cause of the secular acceleration of the moon's mean motion has been one of the leading problems of astronomy for over two centuries. In spite of all the researches of the greatest mathematicians, there remains an outstanding inequality which cannot be accounted for by gravitational or other definite theory. This anomaly is now explained by the fact that the moon is a captured planet, and therefore slowly nearing the earth, owing to the action of a resisting medium, in the nature of cosmical dust pervading the regions where the planets move. The moon was once an independent planet, and when revolving in the region of the asteroids, suffered numerous collisions with satellites; this is the cause of the immense, round, sunken craters which have puzzled astronomers since the time of Galileo. The traditional theory that they are volcanic is quite devoid of foundation, and now definitely and finally disproved.

The roundness of the orbits of the planets and satellites has been remarked from the earliest ages of science, and this phenomenon, which led Plato, Aristotle, and other Greek sages to declare that the heavenly motions are perfect because they are circular, is now shown to be due to the secular action of a resisting medium which has reduced the size of the planetary orbits and well-nigh obliterated their eccentricities; and not at all to these bodies having been detached by rotation and set revolving in orbits which were originally nearly circular, as incorrectly held by Laplace.

Around each planet there circulates a vortex of cosmical dust, of which the satellites alone are large enough and bright enough to be visible in our telescopes. The descent of this material against the surfaces of the sun and planets gives rise to the observed but heretofore perplexing accelerations of the equatorial regions of these globes. The descent of matter upon the sun increases its mass and gives rise to a small secular acceleration of the earth, which, as Mr. Cowell has shown, is also indicated by the observations of the eclipses during the past 3,000 years.

Just as the earth never rotated very rapidly, and has not been appreciably retarded by the effects of tidal friction, so also Venus likewise has escaped a corresponding retardation of axial rotation, and still rotates in 23 hours 21 minutes, as has been held by observers since the days of Cassini, 1667. Accordingly it follows that the conditions of this planet are more like those of the earth than any other body of our system. Mars rotates 41 minutes slower than the earth, while Venus rotates 35 minutes faster; and as the former planet is about as much outside of the earth's orbit as the latter is inside, there is seen to be a profound physical cause which has operated to establish the period of 23 hours 21 minutes first inferred from observations taken over two centuries ago. The planet Venus, therefore, is habitable and probably inhabited by some kind of intelligent beings.

The solar system extends much beyond Neptune, and several of the unseen planets revolving near the outskirts of the system may yet be discovered by observation. Neptune's orbit is too round for it to be the last of the planets, because this roundness indicates that the nebulous medium was quite dense at that distance, and consequently that the limits of the system are much farther out.

It has long been known that the periodic comets are captured bodies which have suffered transformation of their orbits under the action of the planets. The theory is now extended to the planetoids and satellites, and these two classes of bodies are shown to be closely related. The survival of satellites near the principal planets shows that our system was once filled with these small masses. Such moons naturally develop in the condensation of a nebula, and all nebulæ include multitudes of solid globes in addition to the gaseous matter shown by the spectroscope.

The collisions of satellites with the larger globes, as shown by the battered surface of our moon, give rise to part of the light of the nebulæ, and no doubt also to some of the cosmical dust with which they are filled.

The whirling of the spiral nebulæ is due to the unsymmetrical meeting of two streams of nebulosity, which thus coil up, and settle down under the effects of mutual gravitation; or to the mere gravitational settling of a nebula of unsymmetrical figure. The inevitable result is a whirling cosmical vortex, and eventually a star surrounded by a cosmical system is formed.

Nearly all single stars have planetary systems revolving about them, and in the immensity of the starry heavens an infinite number of the planets are habitable, and no doubt actually inhabited. Life is almost as general a phenomenon in the universe as matter itself, though our dominant materialistic philosophy is loth to admit it.

We can see only visual and spectroscopic binary stars in the sidereal universe, owing to the immense distances which render the smaller bodies wholly invisible in our telescopes; but we know, from the example of the solar system and from the causes which have operated in its formation, that planets and satellites exist everywhere about the fixed stars.

In star clusters the motion is shown to be of a spiral character, as in the nebulæ, where we can trace the streams of movement by the nebulosity, and the same theory is applied to the Milky Way. It is shown by calculation based on the best modern data, that the extent of the sidereal universe actually exceeds the vast dimensions found by Sir William Herschel, and of late years held to be extreme.

The modification of the original obliquities of the planets is held to depend on the capture and absorption of satellites. It is shown that in this way the obliquity of Jupiter was practically obliterated. If Saturn's mass were to be augmented till it became equal to that of Jupiter, his obliquity likewise would disappear. The work of Stratton, implying planetary inversion, is shown to be inapplicable to the solar system, because based on a false premise.

The obliquity of Mars is greater and that of Venus probably smaller than that of our terrestrial globe. This is another reason for holding that the planet Venus is habitable, if not actually inhabited. All the principal phenomena of our system are thus harmonized and explained, and the laws are found to be general for the entire sidereal universe.

MIGRATING STARS.

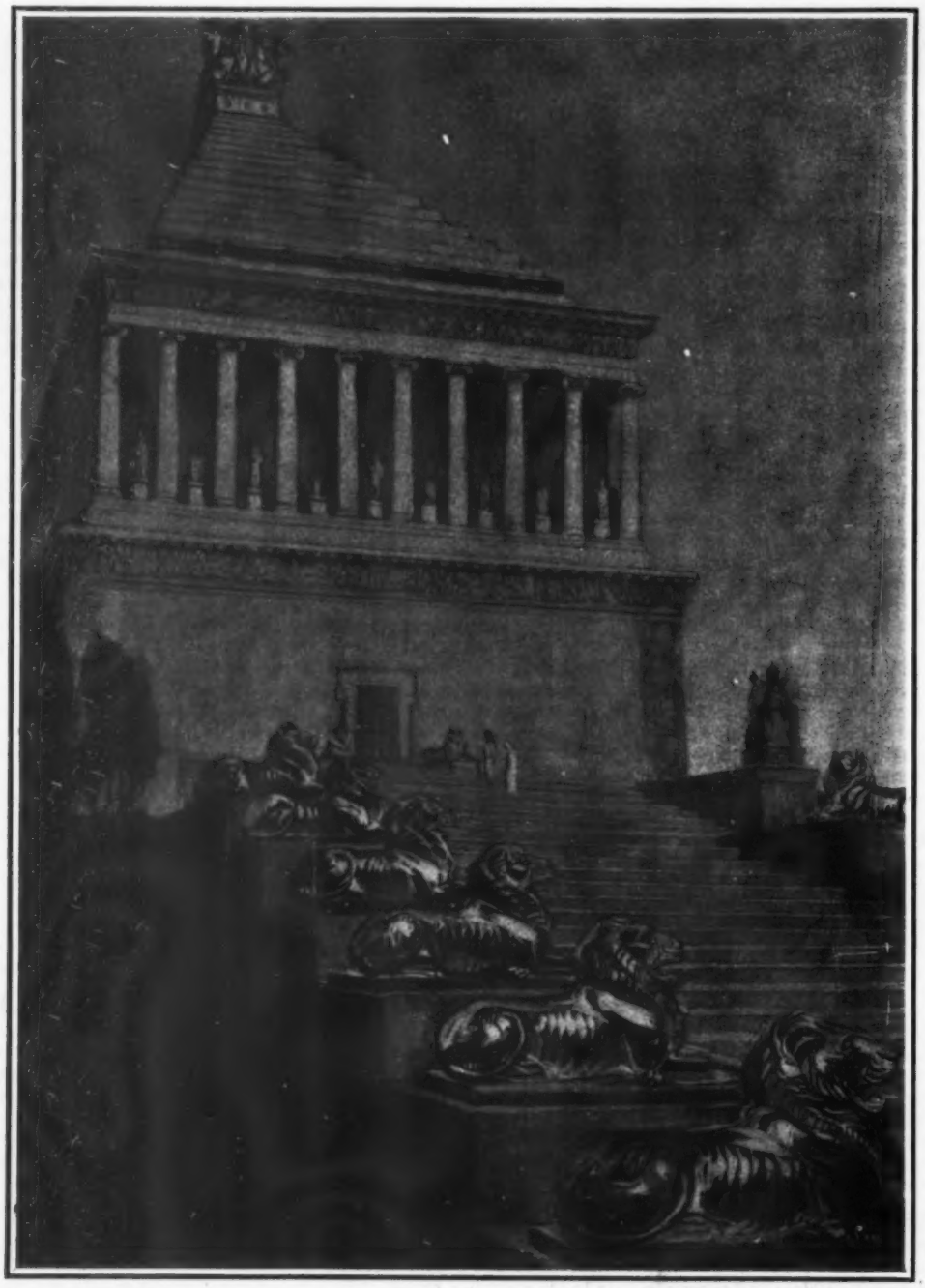
Most readers, of course, know that the constellations of the heavens are only convenient groupings of the stars arranged in ignorance and that the shining suns which appear in them may be void of connection one with the other. Modern astronomy, as Prof. H. H. Turner points out in an article in the Fortnightly, has discovered strange affinities in the movements of stars far removed from one another in the sky. The great seven of the Plow, for example, are not all related. The middle five are speeding in company away from the earth; the two pointers at the end of the Plow are coming toward us. But these two are not alone in the heavens. They belong to the same company as Sirius, to which company belong also six other stars—the brightest star in the Northern Crown, one in the Lion, one in Eridanus, one in Auriga. These have been discovered by Dr. Ejnar Hertzsprung, of Göttingen. They are scattered widely over the sky, and there may be others still undetected. They move in parallel courses through the universe like a flock of migrating birds, and some of this brilliant squadron have passed us by and some have not yet caught us up. It is possible that our sun is one of a cluster of stars moving like this. The variable star Algol may be moving with us; and so may be Beta in the constellation of Perseus and one star of the Eagle and two of the Swan may be going our way. "Migrating stars," the Savilian professor calls these suns whose movements are now under analysis, and their peregrinations are more mysterious than those of any birds. Can it be, he asks, that they have some common association of birth—perhaps some vast nebula collected into stars, billions of years ago, as a cloud condenses into drops, and yet retained in them its vast extension and its primeval velocity?

Prof. Turner has something to say about the "personal equation." If any two people observe a phenomenon—the passage of a star, for example—they will not accredit it with precisely the same period of duration. One observer will be a little slower, one a little quicker than the other; and both will differ from the average. It will usually be found that one is always slower and one always quicker; and the difference of each from the average is a recognized and estimated quantity, which is called the observer's "personal equation." But according to Prof. Turner, the simple notion of a constant peculiarity for each observer has been much elaborated. The personal equation changes if a new instrument be used, or if a fainter star be observed without change of instrument, or as the observer grows older, or as his health varies. On one occasion Prof. Turner was associated with an eminent French astronomer in determining the longitude of Paris, and at dinner with his colleague before beginning the night's observations, ordered a bottle of white wine as a change from the red, which had been customary. His action was not approved. "Ca changera l'équation personelle" was the grave comment. The conception of an observer has, in fact, steadily increased in complexity, until he is now regarded as liable to be deranged by almost every wind that blows; only by multiplying observers can accurate results be obtained, as wisdom comes from a multitude of counselors. Another anecdote is added—that of Prof. Ross's card catalogue of variations in the observations of the stars, which was so precious that in course of compilation it was always kept by the observatory window at Albany, so as to be thrown out—the first thing to be saved—in case of fire.

THE SEVEN WONDERS OF THE WORLD.

BY F. M. FELDHAUS.

THE number seven has always played a prominent part in human life. Hence it is not surprising that seven, and only seven, monumental structures were included in the ancient Greek catalogue of the wonders of the world. The catalogue has been handed down to us by tradition, but the works themselves, with the exception of the Pyramids of Egypt, have either vanished from the face of the earth or exist only as ruins.



By courtesy of the Sphere. From a painting by Kupka.

THE LION-ADORNED STEPS LEADING TO THE TOMB OF MAUSOLUS.

The tomb was partly constructed by Artemesia, the wife of Mausolus, in the fourth century B. C.

THE SEVEN WONDERS OF THE WORLD.

The fame of the Seven Wonders of the World appears to have rested upon their hugeness (real or alleged) and the oddity of their forms and construction. A finer taste, less easily dazzled by externals, would have selected for admiration objects very different from the Egyptian Pyramids, the Hanging Gardens of Semiramis, the temple of Diana at Ephesus, the statue of Jupiter at Olympia, the Colossus of Rhodes, the Pharos at Alexandria, and the Mausoleum at Halicarnassus. With the exception of the Pyramids, the most ancient of all, these structures were products of decadent civilizations, and the description of them conjointly as the Seven Wonders of the World was also made in an age when taste and genius were on the decline. The earliest known attempt to picture them was made in the seventeenth century, after scientists, travelers, and artists of the Renaissance had furnished material for plausible reconstruction. The remarkably versatile Jesuit missionary Athanasius Kircher was born near Fulda in 1601. He traveled far and wide and wrote a goodly number of great folio volumes, illustrated with excellent copper plate engravings. He was especially fond of describing and depicting the wonderful and mysterious. Among the subjects of his books are the Seven Wonders, Noah's ark, obelisk, the interior of the earth, light, and magnetism. His opinions, imposed on his contemporaries by his great personal authority, have been accepted without question until very recently.

The Seven Wonders have enriched modern languages with a number of words—mausoleum, colossal, pyramidal—and the expression Herostratic fame, derived from Herostratus, "the aspiring youth who fired the Ephesian dome."

The Pyramids were built more than four thousand years ago, as monumental tombs of Egyptian kings. Most of them, including the largest, stand in lower Egypt near the west bank of the Nile, where the ruins of sixty-seven similar structures have been found buried under a pall of sand. The largest is the Pyramid of Cheops or Chufu. It was originally 233 meters (764 feet) square at the base and 146.5 meters (480 feet) high, but the length of each side is now reduced to 227.5 meters (746 feet) and the height to 135.2 meters (443½ feet).

Piazzi Smyth, late astronomer royal for Scotland, and a publisher named Taylor discovered a number of wonderful things in the dimensions of the Pyramid of Cheops, for example, that the height bears the same ratio to the periphery of the base that the radius of a circle bears to its circumference (the ratio 3.14159, denoted by the symbol π). Hence these ingenious investigators inferred that the Egyptians of 4,000 years ago knew the value of π to the fifth decimal place. They found the length of the side of the base equal to one ten-millionth part of the radius of the earth, the height equal to one thousand-millionth part of the distance of the earth from the sun, and obtained a unit of length by dividing the length of the base by the number of days in a year. These discoveries were taken to indicate that the Egyptians knew, long before the time of Pythagoras, that the earth is spherical, and knew its radius and its distance from the sun with greater accuracy than Copernicus or Kepler did!

It is certain, however, that the inclined passage which leads to the interior of the pyramid would, if extended outward, meet the sky very near the point which marked the position of the Pole star 4,000 years ago. Hence the lines of the plan were directed by the stars.

The British investigators also discovered in the Great Pyramid the correct value of the density of the earth and found that its mass was equal to that of the earth divided by 10^{15}. Hence they concluded that it was designed to serve, not as a tomb, but as an eternal record and monument of scientific discoveries and standards of measurement. But as the oldest known mathematical treatise, the Rhind papyrus, written about 1500 B. C., contains only the merest rudiments of arithmetic, it is not likely that the Egyptians were familiar with advanced mathematics a thousand years earlier.

The Hanging Gardens of Babylon, which were supposed to have been constructed by the more or less fabulous queen Semiramis, owe their celebrity to the fantastic descriptions given by Roman and Greek writers. Recent excavations have shown the gross exaggeration and fictitious embellishments of these accounts. The mighty Babylon of the classic authors has shrunk to one-fiftieth of its traditional area as a result of thorough study of the cuneiform inscriptions. The immensely high and thick walls, with their hundred gates, appear to have been largely works of the imagination.

Yet it is not surprising that Greek merchants and other travelers, visiting the ancient metropolis on the Euphrates in the fifth and sixth centuries before our era, were amazed by the size and wealth of the city and the magnificence of its palaces and other buildings, nor is it surprising that they embellished the stories which they carried home. Recent explorers claim to have found the Hanging Gardens of Semiramis in the ruins of the third palace of Nebuchadnezzar, who reigned from 605 to 561 B. C. This palace or garden stood on a broad platform supported by foundation walls 100 feet in height, the ruins of which lie buried in the hill called Babil just within the north wall of the city. An inscription of Nebuchadnezzar informs us that the third palace was erected "where the brick wall meets the north wind." Rassam claims to have found remains of wells or shafts, through which water was raised to the terrace. The bricks of this royal palace are now being used in building a dam across the Euphrates.

Interesting in this connection are the words of Frontinus, who superintended the construction of the great aqueducts of Rome, 1,700 years ago: "Can one compare with these wonderful aqueducts, which supply so

many needs of humanity, the useless pyramids and other famous structures?"

On the night when Alexander the Great was born, in the year 356 B. C., a youth named Herostratus set fire to the Temple of Artemis, or Diana, at Ephesus, with the avowed object of making his name immortal. He was put to death and it was decreed that his name should be omitted from the records. But his name was rescued from oblivion and so his longing for posthumous fame has been gratified. The temple, the erection of which had occupied 120 years and cost a fabulous sum of money, was rebuilt after the conflagration by the united efforts of all the princes of Asia Minor on so magnificent a scale that it continued to be reckoned among the Seven Wonders. It was four times as large as the Parthenon at Athens, glittered with gold and gems, and contained 127 columns, adorned with reliefs, in honor of the 127 princes who had impoverished themselves—or their subjects—in its construction. The fame of Diana of the Ephesians is attested by the New Testament. The restored temple was de-

"OSIRIS, KING OF THE NORTH AND SOUTH, MEN-KAU-RA, LIVING FOR EVER. THOU SHALT NEVER MORE HAVE ENEMIES, O KING OF THE NORTH AND SOUTH, MEN-KAU-RA, LIVING FOR EVER."—INSCRIPTION ON THE COFFIN OF PHARAOH BURIED IN PYRAMID.

The Pyramids imposed on the classic imagination as much as they do on the modern mind. They owe their endurance to extreme simplicity of form. In the foreground of this picture the priests are burning offerings at the shrine constructed between the gigantic paws of the Sphinx. The remains of the paws have silted up and have largely disappeared from view.

By courtesy of the Sphere. From paintings by Kupka.

BABYLONIAN CAVALCADE PASSING OVER TEMPORARY BRIDGE IN FRONT OF THE FAMOUS HANGING GARDENS OF BABYLON.

The hanging gardens did not really hang but were raised above one another in terraces as shown in this picture.

THE SEVEN WONDERS OF THE WORLD.

stroyed by Constantine and even its ruins have entirely vanished.

To the Greeks the ideal image of their principal deity, Zeus, the Latin Jupiter, was the colossal statue at Olympia, the site of their most celebrated national athletic contests. The statue was the work of the famous sculptor Phidias, the friend of Pericles. The seated figure was 40 feet high, and was supported by a pedestal 12 feet broad. The nude upper part was of ivory, the draperies of gold, the right hand grasped the globe of the earth, the left the scepter adorned with the eagle. Figures of Victory and dancing Hours and Graces surrounded the throne, which was adorned with numerous figures in relief. According to Strabo, this great statue was housed in a temple so ill proportioned to it that Jove could not have stood up without knocking his head against the roof.

The Colossus of Rhodes was a bronze statue of Apollo, the god of the sun, about 110 feet high, which according to tradition straddled the entrance of the harbor of Rhodes. It was completed, after twelve years' labor, in the year 285 B. C. Fifty years later it was destroyed, with a large part of the city, by an earthquake and its reconstruction was prohibited by an oracle. When the Arabs conquered the island of Rhodes in the seventh century the Mohammedan commander sold the remains of the colossus to a Jew from Edessa and 900 camels were laden with its fragments.

The most renowned of the few lighthouses of antiquity was one erected, according to tradition, in 283 B. C., on the little island of Pharos in the harbor of Alexandria. Its height is given as about 560 feet, its cost as 800 talents, equivalent to $90,000. The Pharos was standing at the beginning of the fourteenth century. It has since been destroyed, but the time and manner of its destruction are unknown.

The list of the Seven Wonders, which began with the Pyramids, ends with another royal tomb, the Mausoleum at Halicarnassus. This monument was erected about 350 B. C., by Mausolus, king of Caria in Asia Minor, in honor of his deceased consort Artemisia. It was 164 feet high, and nearly 500 feet in circumference at the base. Its broad and lofty dome was supported by many columns and surrounded by a colonnade. The building was overthrown by an earthquake in the thirteenth century and its ruins furnished the Knights of St. John with material for the construction of a castle.

All of the Seven Wonders were situated on the shores of the eastern part of the Mediterranean. If the Greek writers had been better acquainted with the north of Europe or the south of Asia they would probably have made a different selection. Near Salisbury in England, for example, stand the cyclopean remains of the very ancient temple of the sun, which are known as Stonehenge, and near Delhi in India stands a huge consecrated column of *iron*, the casting of which would tax the resources of the best of modern foundries.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Gartenlaube.

THE WRIGHT INJUNCTION.—I.

EXTRACTS FROM THE COURT'S OPINION AND THE BRIEFS.

JUDGE HAZEL, of the Circuit Court of the United States, in Buffalo, granted, on January 3rd, a preliminary injunction to the Wright company restraining the Herring-Curtiss company and Glenn H. Curtiss from manufacturing, selling or using for exhibition purposes the Curtiss aeroplane.

Following is the opinion rendered, reprinted from Aeronautics, almost *in toto*. Starting out with a statement of why a gasless flying machine flies, the Judge then cites paragraph 7 of the Wright patent, saying:

"The claims relied upon are the seventh, fourteenth, and fifteenth. It is sufficient to here set forth the seventh claim, which in broad terms includes both the monoplane and biplane types of apparatus:

"'7. In a flying machine, the combination with an aeroplane, and means for simultaneously moving the lateral portions thereof into different angular relations to the normal plane of the body of the aeroplane and to each other, so as to present to the atmosphere different angles of incidence, of a vertical rudder, and means whereby said rudder is caused to present to the wind that side thereof nearest the side of the aeroplane having the smaller angle of incidence and offering the least resistance to the atmosphere, substantially as described.'

"The essential elements of such claim are an aeroplane or supporting surface, the lateral portions of which are capable of adjustment to attain different angles of incidence, and a vertical rudder in the rear of the machine. Claims 14 and 15 included as elements a horizontal rudder, which is positioned forward of the machine, and means for raising and lowering it so as to present its upper or under side to the pressure of the wind."

Judge Hazel goes on to explain that the surfaces of the Wright machine "are connected together by upright stanchions extending lengthwise on the extreme front and rear portions thereof, and are fastened on top and bottom of the planes by universal joints so as to permit the planes or surfaces to yield to pressure and incline upward and downward at their lateral edges or marginal extremities when the cord or rope fastened to the cradle is manipulated by the aviator. This lateral yielding, warping or distorting of the aeroplane is the essential feature by which the equilibrium is secured. Its importance cannot be overestimated, as it is shown that long before the Wright invention a method was sought by which equilibrium in mechanical flying could be secured and maintained. Not only the conception of the idea of securing and maintaining equilibrium in the air, but the appliances—the dynamic cause to achieve the result—originated in the minds of the patentees and took shape and form in the evidently simple method of slightly turning up and down the lateral ends or margins of the planes, thus securing different angles of incidence. The insurmountable obstacle with which prior inventors in this art struggled for years was the precipitate unbalancing or upsetting of the apparatus, and such prior flying machines were therefore incapable of flights with any appreciable degree of success. The affidavits indicate that the patentees did not use the means or identities of prior flying machines, but solved the problem of maintaining equilibrium or lateral and front and rear balance by the introduction of new and practical elements and became pioneers in the field of flying machines of the so-called heavier-than-air type. True, some of the elements of the claims were old, and also shown in the prior gliding machines, but such machines without the combination which included a method of maintaining equilibrium or lateral balance were utter failures. Hence the prior patents and publications apparently do not anticipate the Wright patent, and the claims in controversy are entitled to a broad and liberal construction.

"The Wright patent is unadjudicated, but such fact will not deprive the claimant of its right to enjoin infringement, save where the prior act shows sufficient ground to doubt the validity of the patent."

It is argued by the Judge in the present case "public acquiescence is claimed," it appearing that Wright machines have made "notably successful flights in France, Germany and the United States." He recites the first flight to which the attention of the public was attracted, that at Kitty Hawk, in December, 1903, and points to the heralding by the newspapers of the country of the marvelous success attained, that human flight had at last been first made possible by the Wrights. He calls attention to public recognition of their success by organizations and by the presentation of medals, citing two cases where such testimonials have been entitled to weight in support of the presumption of validity and practical utility. That both Curtiss and Herring obtained "detailed information prior to the construction" of the Curtiss machine, as to experiments made by the Wrights on "the pressure of wind on curved and flat planes and mode of maintaining equilibrium in flights, the former through correspondence" between the Wrights and Lieutenant Selfridge and "the latter from personal observation and investigation by Herring" at the Kitty Hawk camp, is set forth by the Judge.

He mentions Herring's affidavit, in which Herring asserts that he considered the Wright invention was "limited to the lateral warping of the planes, and not that it covered broadly the feature of lateral balancing."

This brings the Judge to the question of whether the Curtiss machine infringes the Wright. He says:

"Defendants claim generally that the difference in construction of their apparatus causes the equilibrium or lateral balance to be maintained and its aerial movement secured upon an entirely different principle from that of complainant; that defendants' aeroplanes are curved firmly attached to the stanchions and hence are incapable of twisting or turning in any direction; that the supplementary planes or so-called rudders are secured to the forward stanchion at the extreme lateral ends of the planes and are adjusted midway between the upper and lower planes with their margins extending beyond the edges; that in moving the supplementary planes equal and uniform angles of incidence are presented as distinguished fram fluctuating angles of incidence. Such claimed functional effects, however, are strongly contradicted by the expert witness for complainant. Upon this contention it is sufficient to say that the affidavits for the complainant so clearly define the principle of operation of the flying machine in question that I am reasonably satisfied that there is a variableness of the angle of incidence in the machine of defendants which is produced when a supplementary plane on one side is tilted or raised and the other simultaneously tipped or lowered. I am also satisfied that the rear rudder is turned by the operator to the side having the least angle of incidence and that such turning is done at the time the supplementary planes are raised or depressed to prevent tilting or upsetting the machine. On the papers presented I incline to the view, as already indicated, that the claims of the patent in suit should be broadly construed; and when given such construction, the elements of the Wright machine are found in defendants' machine performing the same functional result. There are dissimilarities in the defendants' structure—changes of form and strengthening of parts—which may be improvements, but such dissimilarities seem to me to have no bearing upon the means adopted to preserve the equilibrium, which means are the equivalent of the claims in suit and attain an identical result.

"Defendants further contend that the curved or arched surfaces of the Wright aeroplanes in commercial use are departures from the patent, which describes 'substantially flat surfaces,' and that such a construction would be wholly impracticable. The drawing, Fig. 3, however, attached to the specification, shows a curved line inward of the aeroplane with straight lateral edges, and considering such drawing with the terminology of the specification, the slight arching of the surface is not thought a material departure; at any rate, the patent in issue does not belong to the class of patents which requires narrowing to the details of construction."

The Mattullath patent application is thrown out of consideration "as an unsuccessful experiment."

The date when machines alleged to be infringements of the Wright first made their appearance is now put on record. The Judge states:

"Indeed, no one interfered with the rights of the patentees by constructing machines similar to theirs until July, 1908, when Curtiss exhibited a flying machine which he called the 'June Bug.' He was immediately notified by the patentees that such machine with its movable surfaces at the tips of wings infringed the patent in suit, and he replied that he did not intend to publicly exhibit the machine for profit, but merely was engaged in exhibiting it for scientific purposes as a member of the Aerial Experiment Association. To this the patentees did not object. Subsequently, however, the machine, with supplementary planes placed midway between the upper and lower aeroplanes, was publicly exhibited by the defendant corporation and used by Curtiss in aerial flights for prizes and emoluments. It further appears that the defendants now threaten to continue such use for gain and profit, and to engage in the manufacture and sale of such infringing machines, thereby becoming an active rival of complainant in the business of constructing flying machines embodying the claims in suit, but such use of the infringing machine it is the duty of this court on the papers presented to enjoin.

"The requirements in patent causes for the issuance of an injunction *pendente lite*—the validity of the patent, general acquiescence by the public and infringement by the defendants—are so reasonably clear that I believe it not improbable that complainant may succeed at final hearing, and therefore, the *status quo* should be preserved and a preliminary injunction granted. So ordered."

EXTRACTS FROM BRIEFS.

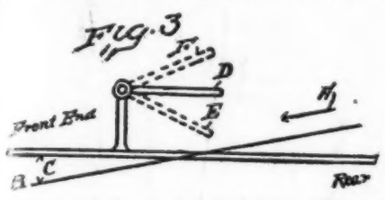
It would be impossible to abstract the briefs submitted in the Wright-Curtiss injunction suit. A great deal of space is taken up in Mr. Toulmin's brief in going into the history of aviation, and to the riddling of A. M. Herring's affidavit to the effect that in 1894 he made use of movable auxiliary surfaces.

The question of whether or not movable auxiliary surfaces, or popularly "wing tips," are infringements of the Wright patent seems to be uppermost in the minds of the aeronautical public. Less attention has been given the subject of prior art and the question of the front rudder. In the briefs the point as to whether it is necessary with the use of wing tips to turn the rear rudder to the high side is brought out quite prominently.

Herring speaks in his affidavit of the necessity of adjusting a vertical tail whenever the angles of incidence of lateral tips are unequal. He says: "In my 1894 gliding machine I found it necessary to use the vertical rudder in preserving a straight course, when I corrected the side equilibrium by using the auxiliary surfaces." This statement of Herring's seems to contradict the affidavit of Mr. Curtiss, in which he says in regard to his own machine: "There is no necessity or reason for swinging the vertical rear rudder when the balancing rudders are swung, because (as both balancing rudders are of the same size and area and present to the atmosphere the same angle of incidence) the resistance of the forward motion of the machine is the same for each rudder."

HOW EQUILIBRIUM IS OBTAINED.

To explain the securing of lateral equilibrium in the Wright machine, for instance, by increasing and decreasing the respective angles of incidence at opposite sides of the machine, Mr. Toulmin employs the sketch Fig. 3, showing "supplementary plans, wing, tip, or marginal portion" (*D*); "* * * and assume that there is another just like it at the far side." "This adjustment (*E*) will put the supplementary plane or



margin at a greater positive angle of incidence than that of the main plane. * * * If the distant supplementary plane or margin be adjusted up to the angle indicated at *F*, its angle of incidence will have been changed from positive to negative. * * * When, however, the two supplementary planes are adjusted at equal angles from position *D*, taking up positions *E* and *F*, respectively, it will be seen that with reference to line *B*, from which the angle of incidence must be determined, *E* is at one positive angle of incidence and *F* is at a negative angle of incidence less in degree, *F* then offering the lesser resistance to the advance movement through the air. The result would be that the side of the machine having the supplementary plane or margin, *F*, would advance more easily and with greater rapidity than the side having the supplementary plane or margin *E*. This would bring about an undesired turning of the machine, from its intended course, about a vertical axis. Now, then, in the Wright patent this tendency of the machine to so turn on a vertical axis, when the supplementary planes or margin are adjusted to effect a correction of careening or lateral tipping, is compensated for by adjusting a vertical rear rudder, which brings into action the compensating counter-turning forces."

The Wright brief goes on to state that in the Wright machine itself the rear corners of the main planes are adjusted simultaneously "to equal angles from the normal or then inclination of the main aeroplane" and that it follows from the explanation given in connection with Fig. 3, "the two adjusted marginal portions will have different angles of incidence to the line (*B*) of flight * * * and hence will offer different degrees of resistance at the respective sides of the machine." This operation brings about the turning of the machine on its vertical axis and the giving to the right-hand side a higher relative speed and tending to "increase the lifting tendency of the right-hand side, even though the angle of incidence is inferior. If this condition goes on unchecked, the machine will lose its lateral balance entirely and is likely to tip edgewise and fall."

In flying the angle of incidence is stated to be constantly changing, these changes being brought about by necessary manipulation of the front rudder.

CONSTANT VARIATIONS IN ANGLE OF INCIDENCE.

The Wrights say in an affidavit: "The angle of incidence in the main planes varies with every variation in the direction or force of the wind; with every variation in the power of the motor; with every variation of the path of the machine from a uniform line, and with every variation of the load." This is explained as follows: "Since in a flying machine the lift is equal to the total weight of the machine, it is evident that if the speed is increased a smaller angle of incidence will furnish the required lift, while if the lift is decreased a larger angle will be required. It is further evident that when two men are carried the angle will be greater than when one is carried; * * * moreover, when the power of the motor increases or decreases, the speed increases or decreases; * * * even with constant power the speed varies, according to whether the machine is ascending or descending and the angle of incidence correspondingly increases or decreases." They also state that in an hour's flight the angle of incidence will be greater or less than a specified normal angle 59 minutes out of the 60.

Up to this point Mr. Toulmin has avoided making any distinction between supplementary planes (or "wing tips," as popularly called) and the warping of the main plane itself. The words "supplementary aeroplane," "tip," "marginal portion," "supplementary plane or margin" and "wing" are used interchangeably.

In beginning a detailed discussion of the Curtiss machine, attention is called by Mr. Toulmin to the alleged fact that "these adjustable margins constitute, in effect, portions of the aeroplanes" (main supporting surfaces).

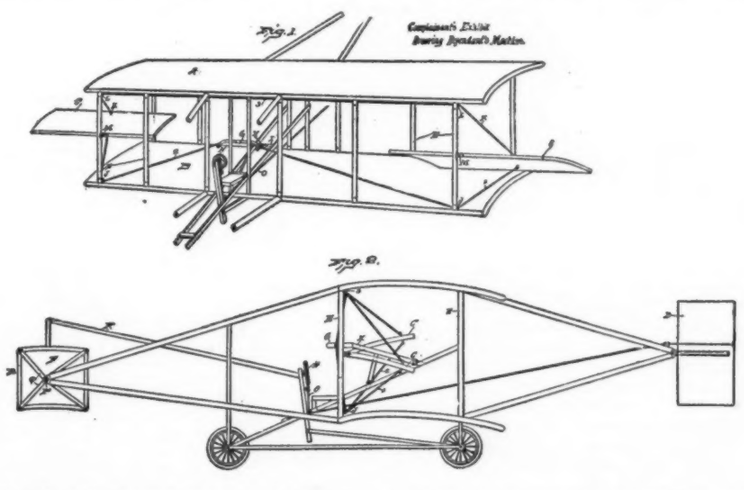
WING TIPPING SAME AS WARPING.

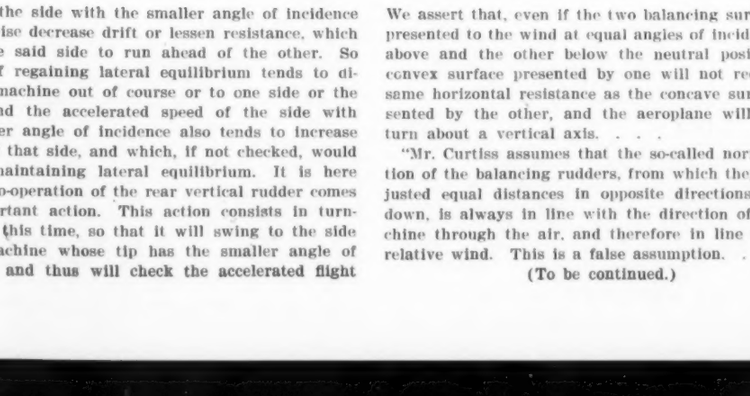
He says: "These marginal portions or tips of defendants' machine are nothing more or less than parts of the main aeroplane set lower than the upper and higher than the lower main plane. They are at the lateral extremities of the machine, just as in complainants' patent; they extend out beyond the more rigid part of the main aeroplanes, just as in complainants' patent. * * * When either of them is at a positive angle it has a supporting function, the same as do the complainants' marginal portions." The function of these is to "maintain the lateral balance * * * while in flight and to control the right and left direction * * * in co-operation with the rear vertical rudder."

The mechanical operation of the Curtiss wing tips is then described. This information has been printed in Aeronautics and is well known, so that it need not be repeated here.

By the mechanical means the Wright affidavit says, "these marginal tips are under the immediate control of the operator and are adjustable to various and different angles of incidence, to different angles relatively to each other and to different angles relatively to the main body of the aeroplanes. That these marginal tips may be all the more in the nature of continuations of the main curved supporting surfaces or aeroplanes, they are made of curved form, with the concave side beneath. * * * When these curved marginal tips are adjusted at equal angles of incidence, the convex surface presented by the one will not receive the same horizontal resistance due to the wind pressure as will the concave surface presented by the other. So this concave-convex formation of these marginal tips produces unequal horizontal resistance at the opposite sides of the machine." * * *

"These margins constantly maintain different angles of incidence to the line of flight, due to the constantly varying angle of incidence of the main surfaces to the line of flight * * *. It will be seen that in defendants' machine, when one side tends to depart from horizontal balance * * * the operator immediately brings the machine back to normal equilibrium by throwing the marginal tip downward at the side of the machine which it dropped too low * * * and by raising the marginal tip upward at the side of the machine which is too high. * * * In this way the lateral equilibrium is regained. But the marginal tip with the greater angle of incidence, while having a greater lifting effect, will also produce increased drift, or retardation of the speed, of that side of the machine,





and, too, the side with the smaller angle of incidence will likewise decrease drift or lessen resistance, which will cause said side to run ahead of the other. So the act of regaining lateral equilibrium tends to divert the machine out of course or to one side or the other. And the accelerated speed of the side with the smaller angle of incidence also tends to increase the lift of that side, and which, if not checked, would prevent maintaining lateral equilibrium. It is here that the co-operation of the rear vertical rudder comes into important action. This action consists in turning it, at this time, so that it will swing to the side of the machine whose tip has the smaller angle of incidence, and thus will check the accelerated flight of that side and hold the machine to its true forward course, without lateral divergence, while the act of recovering later balance is in progress through the increased lift at the side where the tip has the greater angle of incidence. That the operator in defendants' machine can perform these operations, he keeps himself constantly connected with the operating means by which these marginal tips and this rear vertical rudder are actuated. For actuating this rear vertical rudder he utilized a hand wheel, with which is connected the cable, that extends to the rudder. So when he shifts the yoke or cradle, *G*, with his body, he likewise adjusts the rudder with the wheel to the extent required. We state to the Court that such is the operation of defendants' machine, the disingenuous statements as to the rudder made in defendants' affidavits not stating the real facts in regard to the uses of this rudder. Mr. Curtiss even says he can leave off the rear vertical rudder, but we state to the Court that he has made no flight, and could make none, without the presence and use of this rudder, as we here describe the same."

Mr. Toulmin continues: "The remaining feature of the defendants' machine * * * is the forward horizontal rudder. * * * The angle of the surfaces * * * can be adjusted to different angles of incidence so as to cause the machine to tend upward or downward and thus control its horizontal course. This forward rudder co-operates with the adjustable tips, *C*, *C*', in controlling the up and down direction, while and at the time the horizontal balance is being controlled; and also co-operates with the marginal tips should they be in a neutral position, and thus tend to act as supporting surfaces."

"It now sufficiently appears that the mechanism, mode of operation and result of defendants' machine correspond exactly" with the same disclosed in the complainants' patent. (Claims 7, 14 and 15 cited and comparisons made with the Curtiss machine.)

"HERRING OUGHT TO KNOW BETTER."

Alleging that the Curtiss side bases its contention on the theoretical assumption, "an assumption utterly without foundation in fact, impossible in flight, and contradicted moment by moment as defendants' machine flies," that the Curtiss machine in flight maintains one certain angle of incidence, in which "assumed position they say their marginal tips are at equal angles above and below the air pressure line," Mr. Toulmin fires a broadside of language when he says: "The defendant Curtiss knows better; the defendant Herring ought to know better, and defendants' counsel, who acted as expert, knows nothing about the matter."

WRIGHTS CLAIM CURTISS WING TIPS CURVE.

Referring to a blue print put in evidence by the Curtiss forces showing the defendants' balancing rudders, the Wright brothers testify: "Mr. Curtiss is disingenuous in that he represents these balancing rudders as planes, whereas in fact they are segments of cylinders having the convex side upward and concave side downward, and are arched in the same direction as the main planes. . . . We have confirmed this fact by personal examination of the defendants' machine. . . .

We assert that, even if the two balancing surfaces are presented to the wind at equal angles of incidence, one above and the other below the neutral position, the convex surface presented by one will not receive the same horizontal resistance as the concave surface presented by the other, and the aeroplane will tend to turn about a vertical axis. . . .

"Mr. Curtiss assumes that the so-called normal position of the balancing rudders, from which they are adjusted equal distances in opposite directions up and down, is always in line with the direction of the machine through the air, and therefore in line with the relative wind. This is a false assumption. . . .

(To be continued.)

AN INTERNAL-COMBUSTION PUMP.—II.*

APPLICATIONS OF A NEW PRINCIPLE.

BY HERBERT A. HUMPHREY.

Concluded from Supplement No. 1780, Page 103.

EFFICIENCY TESTS.—The first experiments were carried out at Brimsdown, but in the early part of 1908 a testing station, especially designed to facilitate the testing of the pumps, was erected on the ground belonging to the South Staffordshire Mond-Gas Company at Dudley Port. Mond producer-gas, electric current, compressed air, and a good supply of water, were all available at the site chosen, and the plant erected by the Pump and Power Company, which controls the author's patents, is illustrated in Figs. 11 to 14, annexed. The building for containing the pump is fitted with an overhead crane for lifting off the cylinder cover of the pump and demonstrating how quickly the few working parts can be changed. The pump itself is shown, and the delivery main passes into an air vessel upon which any pressure can be put by means of compressed air. The outlet from the air vessel is connected to the measuring tank, which contains perforated baffle plates to stop eddy currents, and in the bottom of the tank is fixed a casting which receives any one of a number of accurately-made sharp-edged orifices, through which the water flows into the large water stock tank below. An accurately graduated gage is fixed close to the orifice to show the height of the surface of the water above the sharp edge of the orifice; and when this height and the size of the orifice are known, the quantity of water passing through the measuring tank can be readily ascertained through the well-known formula:

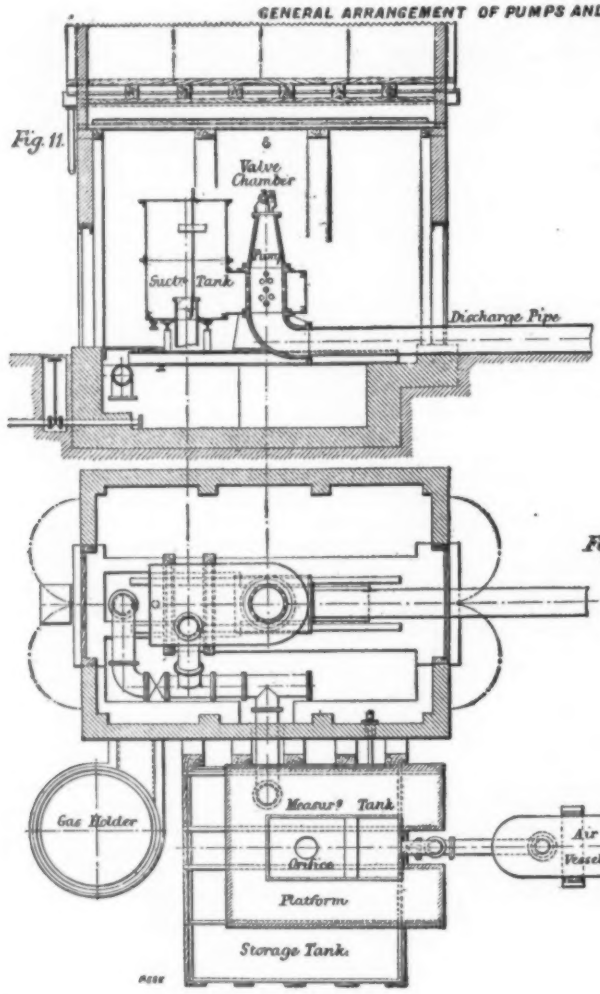
$$\text{Gallons per second} = 6.24\, k\, A \sqrt{2\, g\, H}.$$

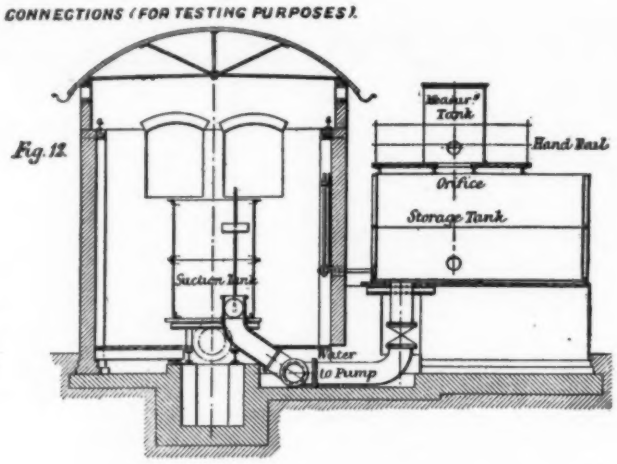
Where k = coefficient of contraction of orifice.
A = area of orifice in square feet.
H = head over orifice in feet.

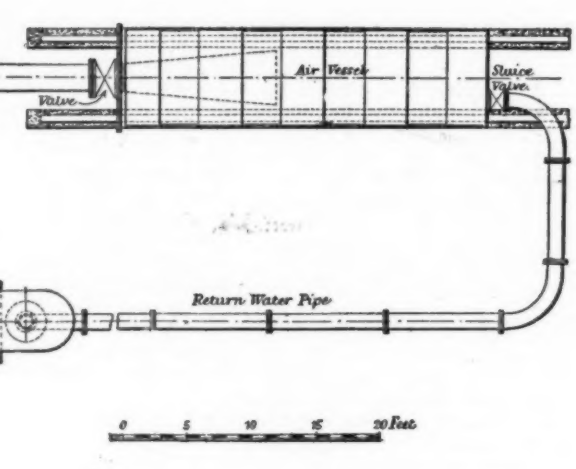
The stock tank is connected by an 18-inch pipe to the suction tank of the pump, and thus the water is merely circulated over and over again. Between the air vessel and the measuring tank there is a valve, so that the flow is throttled at this point in order to maintain the required pressure in the air vessel, and pipe connections are brought from the air vessel and the suction tank respectively to the two sides of a U tube containing mercury, so that the actual lift of the water can be measured on a properly-graduated scale.

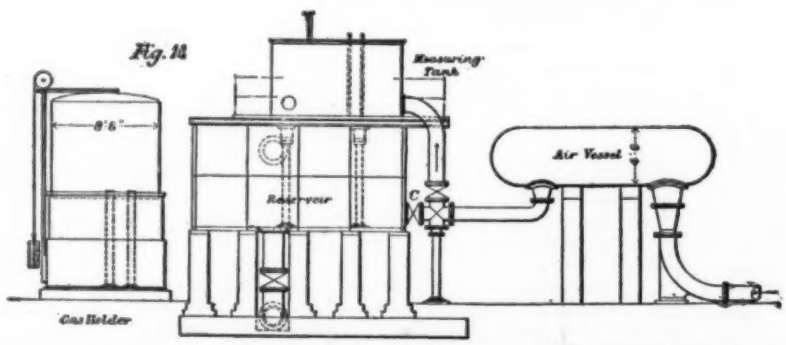
The gas holder for measuring the gas was specially constructed for test purposes. A calorimeter for obtaining the heat value, and the usual appliances for analyzing the gas and burnt products, are included in the equipment.

GENERAL ARRANGEMENT OF PUMPS AND CONNECTIONS (FOR TESTING PURPOSES).









Many tests of efficiency have been made with the plant described, and an official test of a four-cycle Humphrey pump was carried out by Dr. W. Cawthorne Unwin, F.R.S., and his assistant, at Dudley Port, on September 21st and 22nd, this year. A summary of Dr. Unwin's report is added as an appendix, and the results show that with a pump of only 16 pump horse-power the consumption of anthracite coal is 1.06 pounds per pump horse-power hour. This is about half the coal consumption of the highest class of steam pump, and is also considerably less than with an ordinary gas engine driving any kind of pump on the same water lift. With slack costing 6s. 9d. per ton delivered into the Mond producers, the actual cost of slack to yield the 83 cubic feet of gas mentioned in the report per pump horse-power hour is under 0.06d.

Experiments have shown that the pump works extremely well with gasoline supplied through a carbureter, and gives about the same thermal efficiency as when working with Mond gas, but the water delivered from the pump is considerably increased. Water gas has also been tried, with equal success, but so far neither ordinary town gas nor paraffin has been used. Probably ordinary paraffin, in conjunction with a separately-heated carbureter, would form a useful working medium for isolated or contractors' pumping plants.

All the experiments so far have been confined to pumps in which an explosion takes place on ignition, but the author has designed a pump in which the combustion takes place at constant pressure.

Thermal Efficiency.—It has already been mentioned that theoretically the pump cycle is superior to that of the Otto gas engine, or of any other gas engine in which the volume of the expanded products is the same as the original charge volume. In Fig. 15 a curve is drawn showing the theoretical pump-cycle efficiency, assuming that the maximum temperature reached on combustion is 1600 deg. C. Another curve is drawn assuming the maximum combustion temperature is 1000 deg. C. Using Mond gas and low-compression pressures, the second curve more nearly represents the true state of affairs; but as the compression pressure increases, the combustion temperature is also increased, and the first curve is approached. Consequently a curve drawn as shown in dotted lines between these two curves, and passing from the lower to the higher of them, fairly represents the correct theoretical efficiencies when using producer-gas.

This dotted curve has been transferred to Fig. 16

* Paper read before the Institution of Mechanical Engineers, November 19th, 1909.

(below), and plotted against it is the efficiency curve for the Otto cycle gas engine, assuming the working medium in both cases to be air. Mr. Dugald Clerk has shown that the possible efficiency which can be realized in commercial gas-engines of fairly large size is about 71 per cent of the air standard; and, assuming that this ratio also holds good for the pump cycle, we arrive at the two curves given in Fig. 17, in which the attainable efficiencies are compared. It will be noted that although the pump cycle curve is always above the Otto-cycle curve, the efficiencies of the pump are greatly in excess of those of the Otto engine at low compression pressures. This is much to the advantage of the pump, because it enables a good commercial efficiency to be obtained with relatively low working pressures.

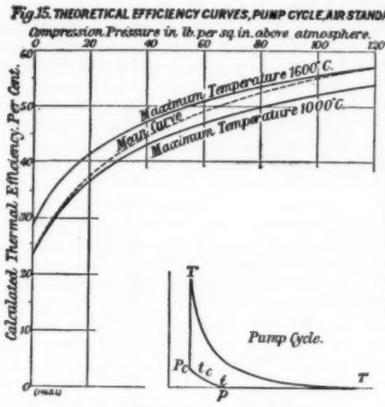
In Fig. 18 the results of Fig. 17 are translated into British thermal units per indicated horse-power hour, so that with any working medium of a given calorific value it is possible to see how the gas consumption varies with different compression pressures.

Application for Power Purposes.—The curves just mentioned are specially interesting because they lead one to recognize the possibility that, as the author's system comes to be developed in the future, internal-combustion pumps may be substituted for gas engines in central electric power stations. If the water pumped is passed through an ordinary water turbine driving an electric generator, and the water is then returned to the pump to be used over and over again, we arrive at a gas-power electric system with the water forming an hydraulic coupling. Even now the combination of the author's pumps with water turbines gives far greater economy than that reached by an internal-combustion turbine so far constructed. It is, of course, dangerous to prophesy, but there is no harm in looking so far ahead into future possibilities in order to see what a central station on the new lines might be like.

Fig. 19 (annexed) shows, in diagrammatic form, a section of such a central station, so as to exhibit one unit of plant, the other units being arranged side by side. The pump discharges through the valve box situated in the suction tank. This tank also serves as an isolating tank. The discharge pipe conveys the water into a large air vessel placed outside the building. This air vessel is connected with other similar air vessels by a common air pipe at the top, which maintains the air pressure the same in all vessels, and a common water main at the bottom. The water is fed to the turbine by a pipe, and the turbine discharges into a longitudinal canal, which has a connection to each of the suction tanks. The turbine is direct coupled to the electric generator, and the current may be taken to the switchboard, which is conveniently placed for overlooking the machinery. The necessary isolating valves are shown, and it will be noticed that the working parts of the pump, as also the turbine and generator, are so situated as to be supervised from a common platform. The gas main runs longitudinally outside the building.

The advantages of such an arrangement are fairly obvious, and arise chiefly from the simplicity of the working parts, the absence of noise and shock, and from the exceedingly low cost of upkeep. In gas-engine stations using cheap producer-gas or blast-furnace gas the cost of lubricants and stores frequently exceeds the cost of the fuel, but in the present instance there is practically no lubrication required, and the author has worked one of his pumps for a week at a time with absolutely no lubrication whatever. Of course, one has to face the loss due to the conversion of the water power into mechanical energy, but the efficiency of a well-designed turbine is not less than 80 per cent at full load, and there is no need to work any of the pumps at less than full load. The ease with which the pumps can be started and stopped from the switchboard gives the electrician complete control of his station and the ability to start up one or more pumps at a moment's notice. In fact, even this arrangement can be simplified, because the governing of the pumps can be so arranged that a steady pressure is kept on the air vessels irrespective of the demands, and a slight rise in this pressure may automatically cut out one pump and its attached dynamo after another, and re-start them again as the pressure falls. Based on the efficiencies so far obtained, a Board of Trade unit can be generated for 2 pounds of anthracite coal, and with the large units of plant required in central stations this figure should be much reduced. Even if the fuel economy should not prove to be higher for such a station, yet its other advantages may more than compensate for this defect. One other aspect of this question might be mentioned, and that is, if the contour of the district is such as to permit the construction of a high-level reservoir of considerable capacity in proximity to the pump house, water can be pumped into this reservoir and be drawn

Fig. 15. THEORETICAL EFFICIENCY CURVES, PUMP CYCLE, AIR STANDARD.



Formulæ for Pump-Cycle Diagram.

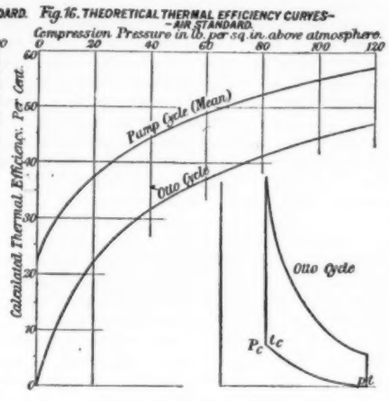
$$\text{Efficiency} = 1 - \gamma\frac{T1 - t}{T - t_c}$$

$$T1 = t\left(\frac{T}{t_c}\right)^{\frac{1}{\gamma}} = t\left(\frac{p_c}{p}\right)^{\frac{\gamma-1}{\gamma}}$$

T = (for curve at 1000 deg. Cent.) = 273 + 1000 deg. Cent. = 1273 deg. Cent. absolute.
T = (for curve at 1600 deg. Cent.) = 273 + 1600 deg. Cent. = 1873 deg. Cent. absolute.
γ = 1.408.
= Suction temperature = 17 deg. Cent. = 290 deg. Cent. absolute.

Adiabatic compression and expansion.

Fig. 16. THEORETICAL THERMAL EFFICIENCY CURVES—AIR STANDARD.



Formulæ for Otto-Cycle Diagram.

$$\text{Efficiency} = 1 - \frac{}{t_c}$$

= 273 + 17 deg. Cent. = 290 deg. Cent. absolute.

$$t_c = t\left(\frac{p_c}{p}\right)^{\frac{\gamma-1}{\gamma}}$$

γ = 1.408.

Fig. 17. PRACTICAL EFFICIENCY CURVE. 0·71 OF AIR STANDARD.

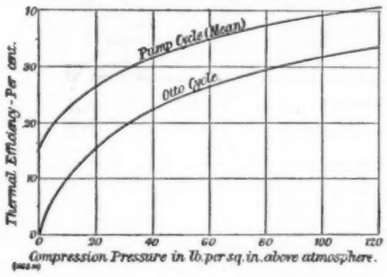


Fig. 18. BRITISH THERMAL UNITS PER I.H.P HOUR. CALCULATED FROM 0·71 OF AIR STANDARD.

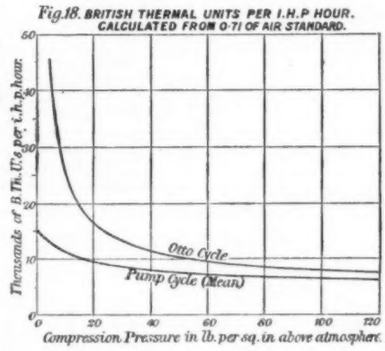


Fig. 19. DIAGRAM OF SUGGESTED CENTRAL ELECTRIC STATION SHOWING HYDRAULIC COUPLING BETWEEN THE GAS POWER AND ELECTRIC POWER.

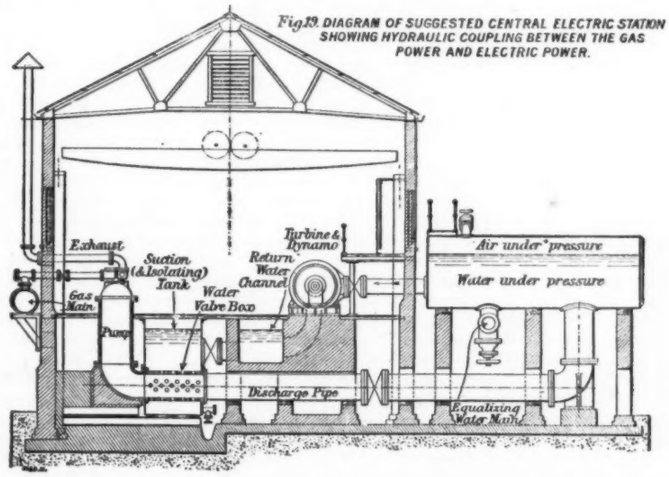


Fig. 20.

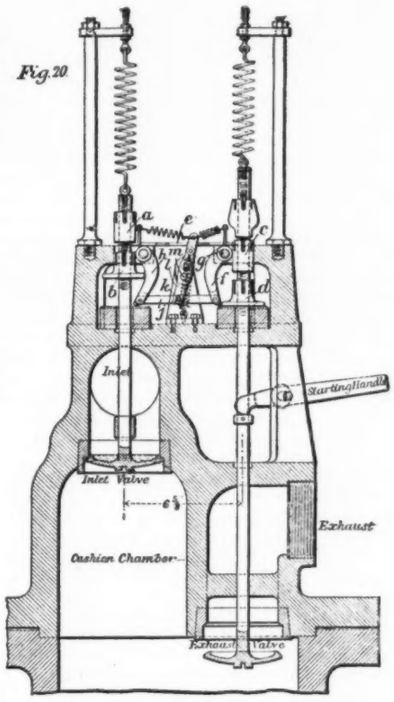
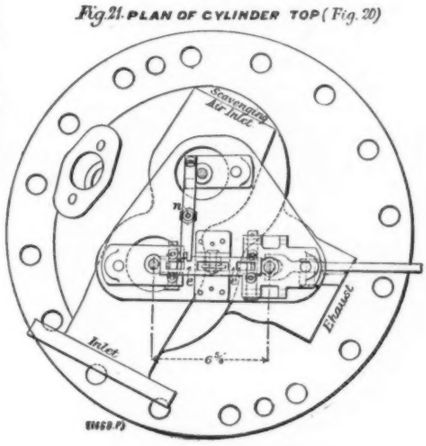


Fig. 21. PLAN OF CYLINDER TOP (Fig. 20)



upon as required. This would enable the pumps to work steadily day and night on a 100 per cent load factor, and would reduce the quantity of plant, in so far as the gas-producers and pumps are concerned, to the minimum possible.

If the internal-combustion pump proves in the future to be a successful competitor of the gas engine for power purposes, then it is probable that one of the most useful fields for its employment will be found in the propulsion of ships. Quite apart from the possibility of driving a turbine attached to a screw propeller, there is the much more efficient jet-propeller, which is the most efficient of all propellers for ships if properly constructed and operated. What has been lacking so far has been a type of pump capable of delivering large quantities of water at comparatively low heads, and it is just these conditions which suit the author's pumps in their simplest form. It would carry us too far to follow up this line, and one must be content with merely throwing out the suggestion, especially as the short time remaining must be devoted to the description of some details of the pump.

Pump Details.—In all the diagrams except the first, the mechanism which controls the valves has been omitted, but in Figs. 20 and 21 some details are presented. These figures represent a recent design of valve chamber, suitable for either a two-cycle or four-cycle pump, the curious fact being that exactly the same mechanism serves for both cycles. During the experiments precisely the same pump and gear was, by altering the conditions, made to operate on either cycle at will. In the figure three valves are shown: the admission valve, the scavenging valve, and the exhaust valve. The last-mentioned valve is situated at a lower level than the others, and above this valve is situated the cushion chamber, which also forms part of the explosion chamber in which the charge is compressed before ignition. The valve stems each carry top and bottom circular nuts *a*, *b*, *c*, *d*. The latter serve to limit the opening of the valve by coming in contact with the rubber buffers, and the top nuts serve to lock the valves in their closed position when the bolt *e* slides between the underside of the nut and the top of the brackets. The remaining gear will be sufficiently understood if its operation is described. Starting with all the valves shut, ignition occurs, followed by expansion. The locking bolts are at this time in such a position that the admission valve is locked and the exhaust and scavenging valves are free to open. The expansion is rapid, and as the point of atmospheric pressure is passed, suction causes the exhaust valve and the scavenging valves to open simultaneously. In the exhaust pipe there is a light non-return valve placed so that it is normally closed. This prevents the suction from drawing back exhaust products, and causes a rush of air past the scavenging valve into the chamber, so that the top portion of the chamber is well swept out. The suction is soon over, and the water column beginning to return, the scavenging valve shuts under the action of its spring, but the exhaust valve remains open while the products are discharged. When the water reaches the exhaust valve, it shuts by impact, and the cushion and cushion-expansion stroke, followed by the suction stroke, results. It will, however, be seen that when the exhaust valve shuts, the enlarged portion of its lower nut, bearing against the curved lever *f*, which is hinged at *g*, forces this lever to the left. As another curved lever, *h*, is hinged to the first lever by means of the link *j*, this other lever has also to partake of the motion and move to the left, thus setting it in position to be acted upon by the lower nut on the inlet valve. Link *j* carries a pin *k*, which engages against a lever *l* hinged at *m* in such a manner that when link *j* moves to the left the top of lever *l* moves to the right. Two springs are shown attached to lever *l*, that on the left being stretched, and that on the right being closed; and as these two springs act upon the bolt *e* in the position shown, the effect is to urge the bolt to the right. This bolt cannot, however, move until the top nut *c* has risen to its full height, which occurs when the exhaust valve shuts. The movement of the bolt then takes place and locks the exhaust shut, at the same time releasing the admission valve. Consequently, when the cushion-expansion stroke is followed by the charging stroke the suction opens the admission valve, and a fresh charge is drawn in. The opening and shutting of the admission valve reverses the action of the gear, locks the admission, and unlocks the exhaust ready for the next cycle. It should be explained that the bolt which controls the scavenging valve is pivoted at *n*, Fig. 21, and has one end fastened to the bolt *e*, so that this end partakes of its motion. Whether the rise and fall of liquid which drives out the products and takes in the fresh charge is due to an oscillation of liquid between the supply tank and the chamber, as in the two-cycle pump, or is due to a reversal of flow in the discharge pipe, as in the four-cycle pump, makes no difference to this gear.

The only other working part is the water-supply valve, which, of course, is purely automatic in its action. A single valve, as illustrated in the diagrams, would need to be too large and heavy to be practicable except for small sizes of pumps. Consequently the single valve is replaced by a number of valves. An arrangement which the author has found very effective is shown in Fig. 22, where a cylindrical valve box is pierced by a number of holes, each fitted with a simple gun-metal valve held on its seat by a light spring. In Fig. 22 the valve box is shown as placed immediately after the pump, and so virtually forms part of the discharge pipe. One very interesting fact should be noted in connection with the water valves. Each valve is normally held closed by a spring of such strength that it readily allows the valve to open when suction occurs. Now suppose that one or more of the water valves is fitted with an attachment which alters the compression of the spring so that the spring no longer brings the valve to its seat under normal conditions. The valve or valves thus fitted do not shut with the other valves, but water flowing through them causes them to shut under the action of the velocity. The result of such an arrangement is important, because it allows the pump to keep on working even if no explosion occurs. Thus, if a charge contains too much gas or air, and fails to explode, it will expand again after compression and be exhausted, and a fresh charge drawn in, the pump continuing to work at the expense of a small quantity of energy representing the amount of water which falls from the high to the low level and escapes past the water valve mentioned. It is not usually desired that this should be a normal condition of affairs, but it is useful at any moment to be able, by moving a lever, to keep the pump running without explosions. By purposely exaggerating this action, and suitably altering the inlet and exhaust-valve mechanism, the pump may be converted into an air-compressor for compressing air by the energy of falling water.

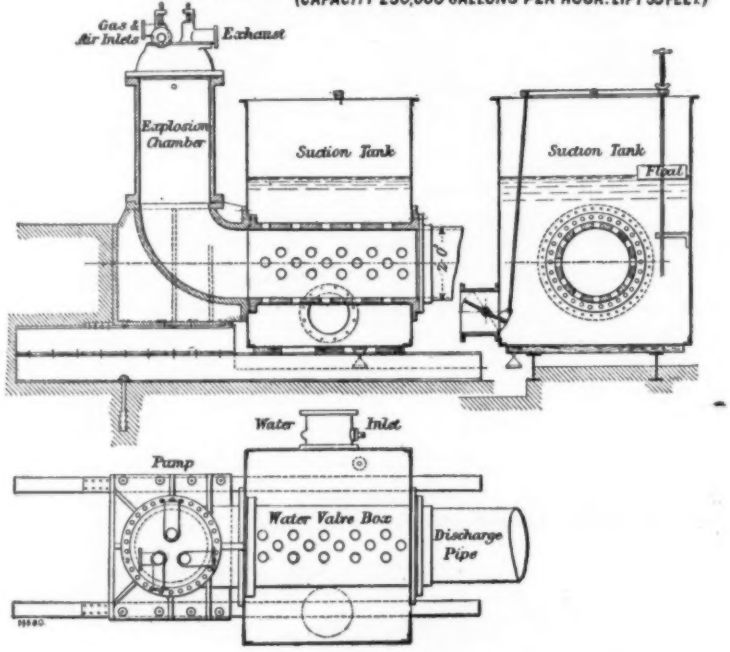
In concluding this paper, the author wishes to express his indebtedness to those of his assistants who have taken an active share in the development of the pumps, and especially to Mr. W. J. Rusdell, who has taken the keenest interest in the experimental work, and who originated the suggestion that the cushion stroke, instead of being produced by an oscillation of the supply water, should be caused by a reverse flow in the discharge pipe, thus making the two-cycle into a four-cycle pump. Mr. Allen Nicholls, B.Sc., has had charge of the electrical ignition devices, and has succeeded in producing a sparking plug which is absolutely reliable when washed by water at each stroke.*

In commenting on Mr. Humphrey's paper, London Engineer critically observes:

Of the future of Mr. Humphrey's pump it is as yet too soon to speak with certainty. That it works and works well in the sizes that have already been made there can be no question, all who have seen it in operation being definite as to the ease and certainty with which it acts. But when the inventor asks us to take long strides into the future and see his pump being used for the driving of central power stations and the propulsion of ships we are disposed to think he is hurrying too fast. It is a long way from 16 horse-power to 10,000, and on the road many unexpected difficulties must be encountered. Mr. Davey in an excellent critical review of the paper pointed out some of them, and particular attention may be directed to his estimate that to pump against a head of 200 feet Mr. Humphrey would require a pipe certainly not less than 600 feet long. Now the construction of a pipe of that length, and 2 feet or 3 feet in diameter, to withstand a high pressure, is no light thing to enter upon. Where circumstances permitted it to be straight the difficulties would be great enough, but if in order to economize space it had to be returned or coiled upon itself, they would be multiplied many times. We are far from saying that mechanical skill could not meet and overcome the difficulties; what we do say is that it is too early even to consider such things, and that years of experience with lower lifts must be passed before high lifts should be attempted. And, indeed, Mr. Humphrey has no need to trouble about high lifts for the present, for his pump with an efficiency greater than that of any other water-raising device at low heads should have a future before it for irrigation, water supply, sewage pumping, and so on, which should be enough to satisfy the inventor. But even for these purposes, although there can be no question about the mechanical operation of the apparatus, there are other questions which must be satisfactorily answered. For example, if potable water is pumped will it, as Mr. Bryan asked, be injured by the absorption of some of the products of combustion? The combustion of ordinary gas is accompanied by the production of sulphur dioxide, which is readily absorbed by water. Does the water delivered by the gas pump show signs of this? We have raised this point with Mr. Humphrey, and he assures us that he has been unable to trace any acidity in the water leaving the pump. That is favorable as far as it goes. Then, again, though there may be no acid is there any fouling of the water by tarry and oily products? Again Mr. Humphrey replies in the negative. But the tests have been, so far, made on a very limited scale, and before a definite decision on such an important point can be given a close investigation will be necessary. These things, however, would not affect the value of the pump at all for dealing with sewage, and probably for irrigation either; but for the latter the inventor has quite another problem before him. A great deal of irrigation pumping is done by oil engines in districts where the production of gas is practically out of the question. Can Mr. Humphrey operate his pump on the lines of the oil engine, and, if so, will the products of combustion still remain innocuous?

These are but a few of the practical considerations that will have at some time or another to be faced, but they do not affect in any way the fact that Mr. Humphrey, having in a most ingenious manner removed all the intermediary gearing between his power and the material that power is to act upon, has produced a pump which is free from the bulk of the mechanical losses to which ordinary pumping engines are subject. His pump has all the thermal efficiency of a gun, in that the explosive acts directly upon the projectile to be expelled. That the superiority of the thermal efficiency claimed by Mr. Humphrey may and will be challenged we do not doubt, and we are not surprised that Mr. Davey, on the one hand, as the champion of steam pumping, has protested against the unconditional statement that the best pumping engines required 18 pounds of steam per pump horse-power—the head should be stated—and on the other hand that Mr. Irwin, as a champion of the ordinary internal-combustion engine, should claim an equal efficiency with Mr. Humphrey.

Fig. 22. PUMP AS DESIGNED FOR THE BRUSSELS EXHIBITION (1910). (CAPACITY 250,000 GALLONS PER HOUR. LIFT 35 FEET.)



* The paper was accompanied by an appendix, giving a summary of Dr. Unwin's report.

LEONARDO DA VINCI.—I.

THE ENGINEER AND MACHINIST.

BY EDWARD P. BUFFET.

THE wise beware of superlatives. To pronounce any man or any machine "the greatest" or "the best," is a presumption which invites contempt. Were the question asked: "Whose is the most exalted genius that the world has known?" it would sound like an idle riddle, to be answered according as the hearers preferred various qualities that enter into a genius. Few Americans, in any event, would cite the name of Leonardo da Vinci. Yet none can examine the relics of that mysterious Florentine without finding proofs of an intellect beside which those of Cæsar and Shakespeare dwindle to meanness.

Leonardo's reputation is well enough established as a painter in a class with Michael Angelo and Raphael, but his name strikes the ear with little suggestion of gifts other than those of a pictorial artist. Yet this was only one manifestation of a mastership which comprehended every branch of art, science, and industry.

No other man ever came near him as a universal genius. None ever had half so many specialized brain cells. In several of his activities independently he is a strong claimant for premiership of excellence, while the combination of his accomplishments makes his superiority overwhelming.

To any mechanic it must be a ground of pride that the artist hand which endowed the Italian Renaissance with works second perhaps in merit to those which remain from the age of Phidias should have busied itself no less eagerly with tasks of engineering and machine design. As a creative power in mechanism the rank of da Vinci is not secondary, but incontestably he is entitled to first place in history.

As we turn over the vast collection of sketch books left by Leonardo, filled with assembled machines and details, roughly outlined like the common-place notes of any present-day designer, yet enlivened with a grace and confidence of stroke, an expressiveness of meaning such as no other draftsman ever gave, there arises a feeling almost of awe and a conviction that nothing which may help us to understand the personality of such an engineer can be without value for his modern fellow craftsmen.

LEONARDO'S MULTIFARIOUS WORKS.

In science and technology he was a true prophet, both as a fore-teller and a forth-teller. So little is known of the mechanical proficiency in his time that we cannot be sure how much of his work was founded on that of others and how much was original. But it is certain that he forecasted the years which were to come after him, outlining the progress of the future by notes and sketches, most of which remained hidden away while other men won fame by puzzling out singly the problems that he had solved *en masse*.

Of the achievements ascribed to him, some may rest on tradition or inference, but very many are amply attested by his own hand. Without pausing to discriminate sharply as to the respective evidence for them, a partial summary of his alleged accomplishments may be given at this point.

Leonardo anticipated Copernicus in forming a just conception of planetary motions. Before Newton he apprehended the principles of gravitation; he was familiar with the laws of motion. He was aware that the earth revolved; he attributed the tides to solar attraction. Like Galileo, he discovered earth-shine on the dark of the moon; he also perceived the burnt-out condition of that satellite. He noted that the apparent size of the stars increases toward the horizon, and he distinguished their scintillation as a phenomenon independent of themselves. He established the relation between the dilation of the eye pupil and the intensity of light. He speaks of "constructing glasses to see the moon large," a single lens though this may be. He is credited with making also a camera obscura. It is said that he invented the barometer afterward realized by Torricelli and directed his studies toward the thermometer, for which Galileo has received honors. He likewise conceived a hygrometer, a compass with movable center and a most improved form of the balance.

While yet Harvey was unborn, Leonardo observed the circulation of the blood. Before Darwin he found in the horse rudimentary muscles and unused organs—a "water stomach." Centuries before Cuvier he reconstructed extinct animals from fossil remains. There have been ascribed to his perception the molecular composition of water, the motion of waves, and the undulatory theory of light and heat. Not only was he skillful in the practice of music, but adept in the theory of acoustics. He built musical instruments on scientific principles, observing the transmission of sound waves in space. He studied the echo and its angle of production; in times of tempest he measured sound velocity.

He studied combustion and called smoke "fire without air," thence inferring that fire feeds on air. He investigated the possibilities of steam power and designed a steam cannon. Steam pumps seem also to have been in his mind. Moreover, there is one of his sketches which, though obscure, has been thought by some to indicate a steamboat.

Mathematics he followed far, and made many geometrical discoveries. He studied the formation of the regular polyhedrons; he was the first in Italy to employ plus and minus signs. One of his myriad mechanical investigations was concerning the power of a lever moved on an inclined plane.

In hydraulics alone he did enough to furnish fame for several men. Until he arose, so far as we know, that branch of physics had been neglected from antiquity. His canal, irrigation, and harbor engineering gave him plenty of opportunities for applying it. Thus, he had occasion to solve such problems as, the quantity of water required to fill a certain canal, and the length of time it should run. In recondite diagrams he depicted the contours of different jets issuing horizontally from orifices. A mill pipe, he found, is not filled by parallel threads of water, but by periodic eddies or currents, the vertical axes of which shift their position.

Many were his inventions relating to this favorite element, water. Pumps of complicated design occupy large space in his books. He designed novel buoys, diving apparatus, and the first life-preserver. Among the earliest canal locks were his. His drawings display dredges of different types and gigantic machines which were to be advanced along the canal bed for systematic digging on both sides.

Liquids were not the only fluids that he studied, but his researches extended to the gaseous realm. Thus, he treated the resistance, or pressure, of the air as dependent on its weight. He measured its density and, as already mentioned, he devised the most important meteorological instruments. His elaborate work in the study and imitation of wings should be classed rather with mechanics than with pneumatics. For he displayed great ingenuity in the design of flying machines, ornithopters, and helicopters. He also knew the use of the parachute.

In Leonardo's industrial machine designing there is most of marvel. Mechanical details that never would be ascribed to the beginning of the sixteenth century and complete apparatus of infinite variety and purpose luxuriate in his huge note books. Cams, levers, gears, worms, ratchets, sprockets, and chains abound in almost every pattern, ancient or modern. We find rolling mills, draw benches, power hammers, cranes, shears, threading machines, file-cutting machines, rope-making appliances, and metal or woodworking tools, such as lathes, planers, boring mills, boring jigs, self-centering chucks, bending machines, and broaches. A stone-cutting saw of his invention is still used in the Carrera marble quarries. He was far advanced in the use of automatic machinery for needle-grinding, gold-beating, and other purposes. He planned many patterns of radius grinders for use in the manufacture of concave reflectors.

During the Medicean age, Florentine fabrics were celebrated; it was therefore natural that some of Leonardo's most recondite designs should appear in textile machinery. He laid out a complicated multiple cloth cutter, a gig, looms, etc. Yet, in da Vinci's time, as in our own the constructive arts were largely subservient to those of destruction. Military engines engrossed an inordinate share of his attention. Those which he designed follow a line of contact between ancient and modern warfare. On the one hand are catapults, ballistas, huge cross-bows bent with windlasses, and instruments for scaling and battering down fortress walls. On the other hand are breech-loading cannon, divers types of artillery carriages, various forms of multiple-barreled guns. He laid out machines for drawing and rolling iron staves used in artillery manufacture and he shows a thorough knowledge of foundry practice. He studied also the composition of explosives. Whether he invented any instruments of torture is not disclosed by a superficial examination of his books, but if he did he found a ready market for them in Italy of his day.

It is hardly necessary to add that Leonardo dabbled in chemistry, particularly in the mixing of pigments, and it is only candid to admit that along this line his results did not uniformly add luster to his reputation. The skill which generally he displayed therein is obscured by certain spectacular failures, much detrimental to his artistic output, as will appear from the sketch of his life hereinafter following.

To prolong adequately this bill of particulars would lead us far into architecture, geology, botany, zoology, anatomy, linguistics, and indeed over nearly all the fields of human knowledge. As has well been said, Leonardo combined the artist's gift of creation with the mechanical inventor's ingenuity and the philosopher's passion for truth. In the third of these characters, as well as the first two, he was gifted to shine; his recorded reflections entitle him to rank as a philosopher; his critical, epigrammatic writings, and his attributed poetical compositions do him credit in the province of literature.

THE MAN, HIS HEREDITY, HIS ENVIRONMENT.

Heredity can no better account for Leonardo than for a white crow. Born 450 years ago (1452) as the natural son of an undistinguished notary and a peasant woman, he entered the world well-favored to perfection, physically and mentally, an anticipatory instance of the superman.

In no way does he appear more to advantage than as tested by that exacting Aristotelian judgment which holds excellence to reside, not in essence, but in proportion; which regards as good or bad that which is fitly or inordinately blended. His moral qualities, like his talents, were tuned to harmony. Reticence and geniality, meekness and self-assertion, peacefulness and belligerency, orthodoxy and heresy, beauty and utility, theory and practice, were adjusted to the finest poise. The sanity of his mind was Grecian, yet better than Grecian; it was that sanity which caused him, a century before Francis Bacon, to let in the daylight of modern applied science.

While no man ever made better use of his opportunities than da Vinci, no one ever lived whose opportunities were better. Standing where he did at the meeting point of the ages, he was permitted to do what no engineer had so freely done before—what no engineer can do now or hereafter—to bring forth out of his storehouse things new and old.

We study ancient history to gratify curiosity or human interest, but we have pressed so far beyond it mechanically that no chance is left of finding anything in it that can help us technically. "In literature read nothing new, in science read nothing old." But when Leonardo came the richest scientific wisdom was in a treasure house of antiquity where it had remained undisturbed for over 1,000 years waiting for him to open the door and make it all his own.

Little vitality had moved in physical learning since the ages when fleets of republican Rome had been enkindled by mirrors of Archimedes; when his analysis had fathomed the dynamic mysteries of water, when Heron's fountains had played in laboratories of Alexandria, and the oil of Carthagenian olives had flowed from Cato's cunningly contrived presses.

Already for a thousand years the dwindling traditions of secular knowledge had been served in the West by the fall of the empire, and since then little care was given to any but superstitious letters. Applied science could scarcely flourish where pure science was abhorred. Chemistry, physics, mathematics, astronomy, were regarded as black arts, and books upon them were burned with the authors, whose condemnation for sorcery, if their intent sufficed, was often not unmerited. Booklore, aside from this, was made up of unprofitable subtleties concerning the dreariest of dogma.

Influences to a revival of learning came not only through chance acquisitions from the East in the Crusades, but through pupilage to the cultured Saracens of Spain, from whom Latin scholars gratefully received algebra and medicine at the universities of Cordova and Toledo. But the new life was directly ushered in by the fall of Constantinople, which drove into western Europe the savants of the Greek empire with their feebly understood, but still cherished, manuscripts of the old philosophers. This occurred a year after the birth of Leonardo, who thus became heir of antiquity.

EXPERIENCE AND UTILITY.

Francis Bacon is credited with having established the modern policy in science. A hundred years earlier, Leonardo da Vinci had laid down that policy and had constantly acted upon it.

Every school boy knows that the novelty introduced by Bacon was inductive reasoning, but every school boy knows something which is not so, for men have always reasoned inductively; the oyster reasons inductively when he learns that opening his shell lets

the water in. Rather, as Macauley has pointed out, Bacon's revolution consisted in turning men from speculation to objects that could be attained only by induction, and by induction carefully performed. The keywords of his doctrine were utility and progress.

Usefulness was despised even by the best and wisest of the ancients. Seneca, the stoic tutor of Nero, rejected as an insult to philosophy the notion that she could have taught the use of metals or improved a ship, plow, or mill. He sought to disprove, as shameful slanders, that Democritus had designed the arch and Anacharsis devised the potter's wheel. "In my own time," he said, "there have been inventions of this sort, transparent windows, tubes for diffusing warmth equally through all parts of a building, shorthand, which has come to such a perfection that a writer can keep pace with the most rapid speaker. But the invention of such things is drudgery for the lowest slaves; philosophy lies deeper. It is not her office to teach men how to use their hands."

Socrates had praised astronomy because its effect is to raise the mind to the region of pure truth. Plato valued arithmetic chiefly for the same reason and he rebuked Archytas for constructing high-power machines on mathematical principles, since this degraded a noble intellectual exercise into a low craft, fit only for carpenters and wheelwrights. Even Archimedes was ashamed that the creations of his genius clothed themselves in matter.

Such were the influences which freed Leonardo's generation from the still more impractical scholasticism of the Dark Ages in which it had been produced; but he was bound no more by classicism than by Medievalism; with the force of his instinct, he burst out to the wider liberty of modernism.

It was creditable for Bacon in the Elizabethan era to declare that trees of learning must be judged by their fruits—not merely by their flowers and leaves—but long before him da Vinci had remarked:

"Mechanics are the paradise of mathematics, because here we come to the fruits of mathematics."

(Te be continued.)

SCIENCE NOTES.

In view of the recent researches as to the action of various rays upon precious stones such as the amethyst or beryl, M. Paul Sacredote notes the effect in the case of the diamond. This is of interest seeing that its chemical constitution is simpler than the others and also that the least changes of color will vary the commercial value of the diamond. He used diamonds from different sources, some of them colorless and others having a slight yellowish tint, and he examined them in turn by the action of the X-rays, with the stone placed outside the tube, also by the cathode rays with the diamond inside the tube, and lastly by the action of heat. The diamond is placed inside a muffle of refractory earth with electric heating, while a thermometer shows the temperature up to 300 deg. C. He finds first that the action of X-rays does not change the color to any noticeable extent. Second, the cathode rays modify the color of the diamond considerably, and the initial hue, white or very light yellow, becomes darker by degrees and takes a light brown tint and this becomes dark brown by prolonging the action. The diamond thus colored appears to keep its hue, since the sample he showed to the Academie des Sciences was prepared about a year ago. It was kept in a box, but at times exposed to the light and on one occasion it was left for an entire day in sunlight. As to the action of heat, from 300 to 400 deg. we find that heat has a decolorizing action so that we can bring back a colored diamond to its initial hue in this way.

The genesis of a new idea is so difficult, and the amount of work necessary for its complete elucidation and development so vast and detailed, that many eminent men, taking only a short period of time and not realizing the minute steps by which the advance of knowledge takes place, have been led to doubt the value of scientific investigation in the higher realms of pure knowledge, even to the extent of speaking of the bankruptcy of science. Others, again, perceiving the apparent aimlessness of many investigations and undervaluing the motive which urges them on, have come to look with a certain contempt upon the man of pure science and his slow and plodding progress. What is the good of all this work at unimportant details? What do you get out of it, and what pleasure do you find in it? they ask, and when they are told that the humble worker usually gets nothing out of his work except the pleasure of doing it, and that his motive is nothing more elevated than the satisfaction of his curiosity, there does appear to be, it must be admitted, some justification for the contemptuous indifference with which the poor researcher is regarded by a considerable section of the population. It is impossible to organize research on a commercial basis. "All attempts," says Prof. Nichols, of Cornell, "at a machine-made science are doomed to failure. No autocratic organization is favorable to the development of the Scientific Spirit. No institution after the commercial models of to-day is likely to be generously fertile. You can contract for a bridge according to specifications. No one, however, can draw up specifications for a scientific discovery. No one can contract to deliver it on a specific day for a specified price, and no employee can be hired to produce it for wages received."

ENGINEERING NOTES.

Bricks and blocks of stone have been manufactured for some years past from a mixture of sand and lime, but little is generally known concerning their strength and durability. In a short paper by Mr. J. C. Stead, which has just been published in the Journal of the Society of Chemical Industry, some of the troubles experienced in the manufacture of large blocks of stone from sand and lime are described, and the faults liable to be found in such stone are mentioned. It is shown that under certain conditions sound stone can be produced on a large scale, but we think that the impression conveyed to most readers by the paper will be that large blocks of artificial sand-lime stone are liable to vary greatly in strength and durability, and that they should not be used in positions of importance. Th stone discussed by Mr. Stead was made by placing a mixture of sand and quicklime in moulds and subjecting the mixture to the action of steam or hot water under a pressure gradually rising to nine or ten atmospheres. The mixture was then cooled, removed from the moulds, and used without further treatment. Mr. Stead's tests show that with a mixture of about 13.5 per cent lime with 86.5 per cent sand it is possible to make stone which will bear a load of over 9,000 pounds per square inch, but with higher and lower proportions of lime the results were not so good.

During the construction of the Pennsylvania Railroad tunnel a deviation from the correct line, apparently caused by a misdirected blast, caused a cavity extending some 3 feet beneath the foundation of the Cambridge Building at the corner of Fifth Avenue. At the same point part of the roadway collapsed, and although the interior cavity was filled in and made secure as far as possible, the road footpath and the building affected continued to settle. In the proceedings of the American Society of Civil Engineers Mr. T. Kennard Thomson describes in detail the injuries caused to the building and various interesting facts brought to light by his investigations into the character of the old pile foundations and the nature of the subsoil. Owing to the presence of water and to the continued settlement of the building the author hesitates to recommend a system of underpinning carried down to rock level, fearing that direct communication might be opened between the cylinder and the tunnel, thereby endangering the entire building. As an alternative he proposed tying back the front wall with steel rods to prevent it from falling away from the remainder of the building. After this operation had been carried out the lessees decided upon cylinder foundations, which were applied in a way constituting a new system of underpinning. For details we must refer our readers to the paper itself. It is satisfactory to note that since the work was completed there has been absolutely no settlement, although subsidence continued up to the time when underpinning operations were commenced.

Notwithstanding its greater tensile strength, mild steel as at present manufactured is far shorter lived than old-fashioned wrought iron. In the atmosphere of large towns, at the seashore where the air carries particles of salt water in damp soil, and in places where stray electric currents prevail steel corrodes with undesirable rapidity. Dr. Cushman attributes the inferiority of modern steel to various causes, chief among which are the presence and irregular distribution of manganese and other metals and the absence of slag. The foreign metallic elements are believed to favor electrolysis, and slag to act as a rust preventive. Within recent years the attempt has been made by an American rolling mill to produce steel with minimum percentages of carbon and manganese and without the impurities that are known to be responsible for corrosion. The product, which is technically ingot iron, appears to be of satisfactory character, if we may judge from a report by Prof. McPherson, of Ohio State University. Test samples of the new material and ordinary mild steel were immersed in a 5 per cent solution of sulphuric acid, with the result that the losses by corrosion were 0.21 per cent and 14.41 per cent, respectively. Other tests of specimens immersed in a 25 per cent sulphuric acid solution consisted of eyebolts, railway spikes, barbed fencing wire, corrugated roofing sheets, and ordinary nails. Without stating the results in detail we can sufficiently indicate the superior qualities of the ingot iron by saying that the proportions lost by corrosion varied from one-fifth to one-thirty-second of the loss from the corresponding samples of steel. The subject is one which our readers should compel British steel makers to take into serious consideration.

TRADE NOTES AND FORMULÆ.

Cement Glue for Fastening Glass to Precious Metal.—Triturate to a fine paste 15 parts of sandarac gum and 5 parts each of marine glue, drying oil, white lead, Spanish chalk, and turpentine. This cement, it is reported, becomes as hard as stone immediately.

Coating for Luminous Paper.—40 parts bichromate of potash, 450 parts of gelatine, 500 parts sulphide of potassium, perfectly dry, are ground and mixed. One part mixed with 2 parts of hot water. Apply several coats, passing through the calendering machine after each coating.

Varnish for Leather.—Dissolve 2.5 parts of true shellac and 0.75 parts of sandarac in 18 parts of alcohol (95 per cent) adding 1 part of turpentine oil; then filter the varnish and grind with 0.75 part of ivory black. The ivory black, being a rather heavy pigment, falls to the bottom if the varnish is kept for a long time; for this reason the bottles in which it is kept or transported should be well shaken before use.

Stick Cement.—Melt 50 parts each of shellac and mastic and 10 parts of turpentine together in a water bath. Allow the mass to cool a little in the vessel and pour it out on to a sheet of parchment paper previously cooled and nailed firmly to a table. Then roll the cement out into thin sticks and, before the latter grow quite hard, bend them into a wave-like form by repeated twisting.

Silver soap is made by dissolving soap in water till it forms a thick paste and adding to the mixture 2 parts of finest white tripoli, 3 parts of powdered chalk and 1 part of jewelers' rouge. Before pouring the soap into forms, a few drops of lavender oil should be added, which will impart a delightful fragrance to the soap and render it more easily saleable than unscented soap, since the "soapy" smell emitted by the latter on contact with water is not agreeable to every one.

India Ink.—I. Work up very finely sifted lamp-black with glycerine and a little size (mucilage) to the consistence of paste; then add a little white of egg and roll out the mass into sticks of about 3 inches in length, the sticks being pressed rather flat. II. Work up fine pine soot with 0.25 part of size and 0.75 part of glycerine to the consistence of a pill and make it into sticks. If desired, a larger quantity of solvent may be added and the compound dispensed in bottles.

Waterproof Paint for Metal.—A solution of 3 parts of Venice turpentine and 1 part mastic, is made in heated oil of turpentine and to this, 96 parts of linseed oil added and the whole heated on the water bath until the odor of oil of turpentine has completely disappeared. With 115 parts of this varnish, rub down 20 parts of well burned freely ground clay, 80 parts of the best Portland cement, 10 parts zinc white and 5 parts of red lead. After the whole has been well ground and thoroughly mixed together, add 25 parts of oil of turpentine.

Ink Pencils.—These are made of graphite and aniline colors, usually methyl violet, these substances being kneaded with water and clay to a plastic mass, which is then formed into small sticks and dried. These sticks when used on dry paper produce a pencil writing which differs from ordinary pencil marks in this respect, that it cannot be removed by a rubber. By means of moistened copying paper several clean copies can be taken. No great pressure is necessary, only stroking with a paper-folder, and the letters will not become blurred.

Cement Glue.—This is composed of 25 parts of Cologne glue, 16 parts of chemically pure white lead, 8 parts of fine zinc white, ½ part of camphor, 14 parts of water, and 1 part of alcohol. First sift the lead and zinc white into a suitable vessel and mix thoroughly, then boil the 25 parts of Cologne glue in 10 parts of water. Pour this glue solution on the white lead and zinc white, and stir till the mass has thoroughly combined. Then add the camphor dissolved in alcohol, continuing the stirring. Now allow the mass to stand, cut it on the following day into small pieces, and put the latter into a boiler provided with two pipes and heated by gas or alcohol, so that the cement melts and runs into the bottles. It is used for cementing porcelain, glass, etc.

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